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ABSTRACT

This publication provides abstracts of papers presented at the 51st annual meeting of the National Association for Research in Science Teaching (NARST) held in Toronto, Canada from March 31 to April 2, 1978. Entries represent a wide range of topics in science education including: cognitive development, teacher education, student behaviors, research methodology, learning theory, post hoc analysis of data, general research, multiple regression analysis, instruction, and curriculum evaluation. (SL)

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NATIONAL ASSOCIATION
FOR RESEARCH IN SCIENCE TEACHING
51ST ANNUAL MEETING
ABSTRACTS OF PRESENTED PAPERS

Hotel Toronto
Toronto, Ontario, Canada
March 31 - April 2, 1978

ERIC Clearinghouse for Science, Mathematics
and Environmental Education
College of Education
The Ohio State University
1200 Chambers Road, Third Floor
Columbus, Ohio 43212

SE 024 050

PREFACE

The ERIC Clearinghouse for Science, Mathematics, and Environmental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the annual conference in Toronto, Ontario, Canada, March 31 - April 2, 1978.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC staff to provide a general format for the abstracts. Special recognition should be given to Dr. James Okey and the NARST Program Committee who obtained the abstracts and organized the program.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Resources in Education, Current Index to Journals in Education and other publications of the ERIC system.

March, 1978

Arthur L. White
Editor

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GENERAL SESSION ONE

Presiding: O. Roger Anderson
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Speaker: Practice Makes Perfect? No,
Practice Makes Theory

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CONCURRENT SESSION A

Session A-1 Critique: Cognitive Development

Presiding:
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Selected Correlates of Piagetian Puzzles

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A Study of Hierarchical Classification in Concrete and Formal Thought

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Discussant: Ann Howe
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SELECTED CORRELATES OF PIAGETIAN PUZZLES

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The search for testing devices, individual and group, clinical and paper and pencil, to measure student's intellectual and conceptual development relative to the Piagetian model will continue. Such measures are undoubtedly of value to the teacher if judiciously employed. The professional will use ratings on Piagetian puzzles and protocols as one more useful set of data to better understand the student and plan learning experiences appropriate to his development.

The purposes of this study were: (1) to identify some Piagetian puzzles as discriminators of Concrete and Formal reasoning in students; (2) to test the intercorrelations of the six puzzles as identifiers of Concrete and Formal reasoning; and (3) to correlate the Piagetian Score with several variables: (a) Student Like or Dislike of Science, (b) Student Perception of Science as Easy or Hard, (c) Student Final Grades in General Science, Physics, Chemistry, Biology, Algebra and Geometry-Trigonometry, (d) Age, and (e) Grade.

The six puzzles employed by the American Association of Physics Teachers in its Workshop On Physics Teaching and The Development of Reasoning, were given to students to determine Piagetian Scores. The answers and explanations to each puzzle were used to classify responses as Concrete or Formal and the number of Formal responses was called a Piagetian Score.

The six puzzles—the Metric puzzle, the Ratio puzzle, the Islands puzzle, the Volume-Displacement puzzle, the Merry-Go-Round puzzle, and the Ticker-Tape puzzle—were given to 465 students in three different junior and secondary high schools in the province of Saskatchewan in which students range from Grade 8 to Grade 12. The tests were also administered to 13 first year students in a university physics class.

Demographic data collected included age, grade and highest level of science studied. In addition, a measure of the student's feeling toward science was requested on a three-point scale ranging from I Like Science to I Dislike Science, and the student's perception of the degree of difficulty of science classes was measured on a five-point scale ranging from Very Hard to Very Easy.

The major findings were:

1. The easiest of the three Piagetian puzzles was the Volume Displacement, the Metric and Ratio being equally difficult since both involve ratio and proportion, but solved by fewer students. The Islands, Merry-Go-Round and Ticker-Tape puzzles did not discriminate among students at this level.

2. The higher the Piagetian score, the more the student liked science.

3. The higher the Piagetian score, the easier the students perceived their studies in science to be.

4. Pearson correlation coefficients between Piagetian scores and final marks in science courses were highest for Chemistry 0.639, Biology 0.579 and Physics 0.529 and lowest for Algebra 0.248. These coefficients were all significant at the 0.05 level.

5. Correlation coefficient found between Piagetian score and age was 0.09 significant at 0.05 level and between Piagetian score and grade was 0.20 significant at the 0.01 level.

A STUDY OF HIERARCHICAL CLASSIFICATION IN CONCRETE AND FORMAL THOUGHT

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The purpose of this study was twofold. First, it was to investigate the relationship of hierarchical classification processes in subjects categorized according to developmental level as defined by Piaget's theory. Second, to gain further information concerning the validity of the hierarchical model and test used in the study.

A hierarchical classification test and a battery of four Piaget-type tasks were administered individually to a group of 60 randomly selected high school students and to a group of 52 randomly selected junior high school students. Students in each group were categorized as concrete, transitional, or formal by determining their performance on the battery of four Piaget-type tasks. The four tasks were: 1) Conservation of Volume using Metal Cylinders; 2) Elusion of Irrelevant Variables (Pendulum); 3) Equilibrium in the Balance; and 4) Proportional Logic and Hypothetical Deductive Reasoning (Stickman). These four tasks were chosen because successful solution of them is indicative of formal operational thought. Scoring procedures used in the study were similar to those reported in the literature (Lawson, et al., 1974).

In addition to the Piaget-type tasks, a hierarchical classification test was administered to each individual within each group. The test consisted of a six-level hierarchy called a Natural Things Test. The first three levels of the test consisted of: 1) attribute identification (non-verbal identification); 2) attribute recognition (verbal naming of attributes); and 3) object recognition (associating names with objects). The final three levels of the Natural Things Test were progressively more general, and hence, more abstract. The final three levels of the test were: 4) Class Recognition; 5) Class of Classes Recognition subsuming one class; 6) Class of Classes Recognition subsuming two classes. To measure all six levels, eight sub-tests were used (two sub-tests were used for Level 4 and Level 5). Administration and scoring of the test were the same as reported in the literature (Lowell, 1977).

Since the hierarchical test used in this study progresses from simple concrete attribute recognition to abstract class recognition, it was assumed that subjects experiencing difficulty on the Piaget-type tasks, indicating concrete thinking, would concomitantly experience difficulty on the hierarchical test, particularly with the last three levels dealing with class recognition. Whereas, students who could perform successfully on the Piaget-type tasks, indicating formal ability, should also perform successfully on the hierarchical test, achieving all six levels without difficulty.

The results, in general, support these assumptions. A Chi-square analysis of hierarchical level against developmental level yielded statistically significant results for both groups. In comparing the performance of those subjects categorized as concrete in both the junior high school and high school groups (mean age = 13.8 and 16.1 years respectively) on the hierarchical test, an unexpected result was noted. The junior high school group performed as predicted on the hierarchical test; however, a similar prediction for the high school group was not supported. Although categorized as concrete, this group experienced little difficulty with the upper levels of the hierarchical test, their performance yielding statistically significant results but in a direction opposite from what was predicted.

Such results suggest that hierarchical classification, while demanding abstract reasoning ability, may be a less demanding cognitive task and hence precedes the learning of more complex relational problems such as those presented by the Piaget-type tasks. In addition, since subjects categorized as concrete were capable of attaining abstract class concepts, while younger subjects similarly categorized were not, a number of questions for further research are raised, particularly to the utility and meaningfulness of using Piaget-type tasks as clear and decisive indicators of cognitive ability.

Lawson, Anton, et al. "Piagetian Formal Operational Tasks: A Crossover Study of Learning Effect and Reliability." Science Education, 58(2), 1974.

Lowell, Walter. "An Empirical Study of a Model Abstract Learning." Science Education, 61(2), 1977.

CONCURRENT SESSION A

Session A-2 Teacher Education

Presiding: Richard L. Campbell
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The Effect of Studying Different Question Classification Systems on Preservice Teachers' Ability to Classify Questions and Attitudes Toward Questioning

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An Experimental Study Comparing the Effect of Three Modes of Instruction on Metric Knowledge and Attitudes of Preservice Elementary Teachers

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Elementary Teacher Attitudes on Teaching Styles in Relation to Their Science Background and Organizational Climate

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and

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THE EFFECT OF STUDYING DIFFERENT QUESTION CLASSIFICATION SYSTEMS ON PRESERVICE TEACHERS' ABILITY TO CLASSIFY QUESTIONS AND ATTITUDES TOWARD QUESTIONING

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Research on improving teachers' questioning level through the study of categorization systems has had generally favorable results (Rogers and Davis 1971, Farley and Clegg 1969, Konestki 1970). These studies made use of a variety of classification systems. Godbold (1973) reports that a substantial portion of the investigations of teacher questioning have employed the Bloom (1956), Aschner (1961) or Sanders (1966) category systems directly or have used instruments derived from them. Although Gall (1970) provides a descriptive analysis of these classification systems, no experimental studies have been conducted to evaluate the comparative efficacy of these programs in terms of student ability and attitude.

The purpose of this study was to evaluate the effect of the three most commonly used question classification systems on preservice teachers ability to classify questions and on their attitude toward questioning.

Procedure

Thirty preservice teachers were randomly assigned to three treatment levels. Level one received two hours of training in a question classification module based on Bloom. Level two received training in a module based on Aschner while the third treatment level participated, for the same amount of time, in a question classification module based on Sander's system. In all cases the modules consisted of a written description of the category followed by practice sessions requiring the students to identify the level of questions presented in a written list. Using Campbell and Stanley (1971) notation, this study can be diagrammed as follows:

$$\begin{array}{cccccc} R & O_1 & X_1 & O_2 & O_3 & O_4 \\ R & O_1 & X_2 & O_2 & O_3 & O_4 \\ R & O_1 & X_3 & O_2 & O_3 & O_4 \end{array}$$

where X_1, X_2, and X_3 = the three treatment levels and,

O_1 = a pretest measuring ability to correctly categorize questions

O_2 = a posttest measuring ability to correctly categorize questions

O_3 = a gain score on the ability to correctly categorize questions

O_4 = an attitude toward questioning measure

Analysis

T tests for dependent samples were used to determine differences between pre- and post-tests measuring ability to classify questions. Analysis of variance procedures were used to determine differences among treatment groups on question classification ability gain scores and on attitude toward questioning. The Newman-Keuls multiple comparison technique was the method of choice for all pair-wise contrasts in the post hoc analysis.

Posttests measuring ability to classify questions were found to be significant ($p < .05$) for two of the classification systems. Results of ability gain scores among treatments showed no significant differences ($p = .09$). No significant differences in attitude were identified.

If one assumes that learning a question categorization system results in improved teacher questioning level (Rogers and Davis 1971, Farley and Clegg 1969, Konetski 1969), then results of this study may be helpful to teacher educators as an empirical basis for selecting a question classification to bring about this improvement.

Aschner, M. J. "Asking Questions to Trigger Thinking." National Education Association Journal. 1961. 50. pp. 44-46.

Bloom, B. S. (Ed.). Taxonomy of Educational Objectives. Handbook 1, Cognitive Domain. New York: David McKarp Company. 1956.

Campbell, Donald T. and Julian C. Stanley. Experimental and Quasi-Experimental Designs for Research. Chicago: Rand McNally and Company. 1971.

Farley, G. T. and A. A. Clegg. "Increasing the Cognitive Level of Classroom Questions in Social Studies: An Application of Bloom's Taxonomy." Paper presented at the American Educational Research Association Symposium on "Research in Social Studies Education." February 1969. Los Angeles.

Gall, M. D. "The Use of Questions in Teaching." Review of Educational Research. 1970. 40. pp. 707-721.

Godbold, John V. "Teacher Training for Effective Questioning." Paper presented at the Annual Meeting of the National Council for Social Studies. 1973.

Konetski, L. C. Instructional Effect on Questions Asked by Preservice Science Teachers. (Doctoral dissertation, Indiana University). 1970.

Rogers, V. M. and O. L. Davis. "Varying the Cognitive Levels of Classroom Questions: An Analysis of Student Teachers' Questions and Pupil Achievement in Elementary Social Studies." Paper presented at the meeting of the American Educational Research Association. Lexington. 1971.

Sanders, N. M. Classroom Questions: What Kind? New York: Harper and Row. 1966.

AN EXPERIMENTAL STUDY COMPARING THE EFFECTS OF THREE MODES OF INSTRUCTION ON METRIC KNOWLEDGE AND ATTITUDE OF PRESERVICE ELEMENTARY TEACHERS

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The Problem. The purpose of this study was to compare the effectiveness of three instructional approaches, expository (T_1), modular (T_2), and gaming (T_3) to teach the metric system to preservice elementary teachers. Specifically, the effectiveness of each approach was determined by its ability to (1) bring about an increase in knowledge of the metric system and (2) create favorable attitudes toward metric measurement. Each treatment was also examined to determine whether differences in metric achievement and attitude would occur as a result of treatment between subject groups identified as high and low mathematics achievers.

The Rationale. It was theorized that the three selected teaching modes represented points along a teaching-learning continuum dependent upon the level of student participation and effort demanded by the mode. Communication theory from attitude research was used to support the hypothesis that the approach which required the greatest effort by the subject would facilitate the greatest cognitive and attitudinal gain. Therefore, because of the high level of effort that would need to be expended by subjects exposed to the gaming treatment, it was hypothesized that a gaming approach would produce the greatest cognitive and attitudinal changes.

The Sample. One hundred forty-one preservice elementary teachers were randomly assigned within six regular class sections to one of three treatment groups. Subjects were then identified as high or low mathematics achievers on the basis of whether their scores fell in either the top or bottom one-third of the rank ordering of scores on a standardized mathematics test. These subjects constituted the sample used for purposes of statistical analysis.

The Treatment and Analysis. T_1 was defined as expository and consisted of a series of three lectures dealing with the metric system which were pre-recorded on tape and supplemented with films and duplicated materials. T_2 was defined as modular. Subjects were directed to complete either in small groups or as individuals six prescribed components followed by self tests. T_3 was defined as gaming, where subjects participated as players on a board game, Decimeter, which can be used to teach a knowledge of the metric system.

Prior to and following the treatment period of three class periods extending over a week, (1) the Trueblood-Szabo Metric Achievement Test and (2) the Shrigley-Trueblood Metric Attitude Scale, were administered. An analysis of variance on repeated measures was the statistical design used and the level of significance for F-values was set at .05.

The Results. The main effect for pre-post testing was significant on both measures. There was no significant difference between treatment means. However, high mathematics achievers improved significantly on the test of metric knowledge as compared to low achievers and a significant interaction occurred between treatment and pre-post testing on the metric attitude measure with T_1 subjects exhibiting the most positive metric attitude change. Therefore, it can be assumed that although the three treatments can bring about a significant change in metric knowledge and attitude after one week of treatment, an expository approach may prove more beneficial for high mathematics achievers for improving metric attitude and that high achievers can be expected to learn more than low achievers regardless of treatment.

ELEMENTARY TEACHER ATTITUDES ON TEACHING STYLES IN RELATION TO THEIR SCIENCE BACKGROUND AND ORGANIZATIONAL CLIMATE

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Design of the Study

Attitudes toward science and science teaching were collected from 504 elementary teachers in 39 randomly selected schools in Nova Scotia (Canada) to determine the effects of organizational climate and the amount of science course background on a student-centered approach to elementary science. Subjects completed the Semantic Differential Test of Teacher Attitudes (SDTTA), the Organizational Climate Description Questionnaire (OCDQ) and items on science courses taken in high school and college (SB). Categories of organizational climate (OPEN, MIDDLE and CLOSED) and science course background (HIGH, MIDDLE and LOW) were calculated and analysis of variance was used to determine significant differences in responses to the SDTTA for 28 groups described by OCDQ and SB categories separately and in interaction. Concepts used on the SDTTA were plotted to locate those with similar meaning.

Conclusions

1. Of the 39 schools taking part, 3 were found to have OPEN climate, 7 were in the MIDDLE category, and 29 were CLOSED. Random selection of most of the sample schools suggests that the majority of schools in the province is closed in organizational climate, a characteristic that is consistent with findings for other provinces and states across the continent.

2. The amount of science taken by teachers was used to derive a score by adding the number of high school courses to twice the number of college or university courses. The mean of all scores was 6.7 and indicates a relatively low level of science exposure for most teachers.

3. Attitudes expressed by the whole sample are not markedly different from those expressed by separate OCDQ and SB groups and show a strong attachment to a more traditional approach to science and science teaching, one in which knowledge is imparted by the teacher to students who listen and occasionally participate actively.

4. Groups categorized by school OCDQ profiles show the main characteristics of the whole sample. OPEN teachers in addition expressed flexibility by their linking of student activity and program structure to the main ideas supported. For MIDDLE teachers strong

positive attitudes toward activity concepts were separately clustered as were those toward structure in programming, which tended to be neutral or mildly trivial, unenjoyable, powerless and difficult. The CLOSED group had negative feelings toward program characteristics. The MIDDLE category attached more importance to an activity-explorative orientation to learning, while OPEN group members were significantly less attached to that approach and to abstractions in science programs. The MIDDLE and OPEN groups seem more eclectic in their approaches rather than being supportive of a particular approach or theory of education.

5. Subject OCDQ profiles were used to form three groups, none of which had a concept significantly different in its mean from other groups. Attitudes toward science are fairly homogeneous when subjects are considered by individual perceptions of organizational climate.

Clustering of concepts indicated distinguishing differences for subject OCDQ groups. From OPEN to CLOSED there is a shift from ease in including activity in science to a desire for orderly exploration and correctness to an expressed need for defined structure in science programming.

6. The largest number of significant differences in concepts was found for teachers classified by levels of science course background. The concepts deal entirely with aspects of science. Teachers in the HIGH SB group find science and the teaching of it more enjoyable and less difficult than do teachers with less science course background. Members of the HIGH SB group find the "facts and concepts" kind of science easier to handle, likely in part, because of their feeling that having a factual science background is neutral in difficulty compared to more difficulty for teachers with lower SB scores.

7. Interaction of school OCDQ categories and SB levels produced significant differences in concept means that identify the CLOSED OCDQ LOW SB group as being more neutral toward playing the role of classroom director while expressing more difficulty and less powerfulness toward exploration in science. Teachers in OPEN and MIDDLE OCDQ groups with higher SB scores ascribe more ease, enjoyment, and power to an active approach to learning which includes doing and directing science activities.

8. Interaction of subject OCDQ and SB dimensions produced significant differences that reflect strength of SB levels: less science background reduces ease with which facts and concepts are presented and increases difficulty with science program structure. Concept clusters include a shift diagonally from OPEN-HIGH to CLOSED-LOW. The former feel importance, enjoyment, power and ease toward laboratory oriented science and less strong feelings toward structure, neatness and their own activities. Toward the CLOSED OCDQ and LOW SB corner, science with a personal involvement and with known outcomes is mildly

important, enjoyable and powerful; structure and testing are of little interest to these teachers.

9. Examination of significant differences among concepts and variations in clustering for groups indicates that teachers who perceive their schools to be more open or who are in more open schools and have higher science course background scores are more likely to have a predisposition toward science and science teaching which is student-centered and also be strongly directed toward student acquisition of information.

Session A-3 Cognitive Development

Presiding: Jane B. Bowyer
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The Acquisition of Propositional Logic and Advanced Cognitive Strategies in Grades 6-14

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The Relationship Between the Proportional Reasoning Ability of Ninth Graders and Their Achievement of Selected Math and Science Concepts

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Actualizing Teaching Intentions by Concrete and Formal Operational Prospective Elementary School Teachers in Nigeria

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THE ACQUISITION OF PROPOSITIONAL LOGIC AND ADVANCED COGNITIVE STRATEGIES IN GRADES 6 - 14

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Within Piaget's theory, formal thought is characterized by the development of a set of operational structures based upon propositional logic. But as Piaget has pointed out, formal thought also entails the development of advanced cognitive strategies governing the understanding and use of concepts such as proportion, probability, and correlation. According to Piaget a developmental synchrony exists among propositional logic and these cognitive strategies in that theoretically they all depend upon the development of a combined lattice and group structure that Piaget views as the basic structure of formal thought.

The purpose of this study was to test this hypothesis of developmental synchrony. The development of advanced cognitive strategies is of importance in that they represent a significant portion of what could reasonably be termed "scientific reasoning." Their relationship to the development of propositional logic is of theoretical interest in that it is here that Piaget's logical analysis of the developing intellect has encountered its severest criticism. If instructional theory practice in the sciences is to become grounded in sound psychological theory, this aspect of Piaget's theory should be investigated.

Five hundred seven students in grades 6, 8, 10, 12, 13 and 14 were selected from a single middle to upper-middle class suburban community in the San Francisco Bay area and two university non-major science courses. An attempt was made to select representative samples from each grade level and control for socioeconomic level across age. Subjects were administered a seven-item pencil and paper test of propositional logic, proportions, probability, and correlations during their regularly scheduled classes. Testing of each class took about 40 minutes. Responses were scored as correct or incorrect. To be correct a response on the proportions, probability and correlations items had to be accompanied by an adequate justification.

As might be expected the sixth graders performed relatively poorly on all items (1.0% to 26.8%) while the college students (grades 13-14) performed the best on all items. Their percentages of success were quite high for the items that involved proportion (80.4%), probability (73.3% and 71.6%), and correlations (61.8% and 67.1%) but were quite low for the propositional logic items (16% and 17%).

In general, the data revealed a gradual but definite increase in subject performance across age on the items that involved the advanced cognitive strategies (proportions, probability, correlations) but revealed no substantial improvement in performance on the propositional logic items. A principal components analysis of the data suggested two developmental trends within the data.

The clear increase with age of subjects' ability to solve problems of proportionality, probability and correlation and the substantial lack in their ability to successfully apply the rules of propositional logic argues against the Piagetian hypothesis of a developmental synchrony. The results of the principal components analysis further suggests that the cognitive strategies investigated and propositional logic do not form a single developmental trend. This finding raises doubts about Piaget's contention that a distinctive feature of formal thought is its reliance upon the development of a set of operational structures based upon propositional logic.

In light of this apparent failure of Piagetian theory to account for the present results, two related questions were raised: (1) What is the nature and structure of formal thought? and (2) What role does propositional logic and advanced cognitive strategies play in the thinking of the adolescent?

The present paper discusses these questions and suggests educational implications.

THE RELATIONSHIP BETWEEN THE PROPORTIONAL REASONING ABILITY OF NINTH-GRADERS AND THEIR ACHIEVEMENT OF SELECTED MATH AND SCIENCE CONCEPTS

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Science education researchers have begun to study student cognition and subject matter difficulty at various grade levels. They have used the Piagetian notion of cognitive development as the theoretical framework to guide their research. These investigations have identified some mismatches between the intellectual competencies of students and the conceptual difficulty of their science curricula. However, many more studies need to be conducted which investigate the relationship between specific cognitive structures and specific science concepts.

The purpose of the present study was to investigate the relationship between proportional thinking and students' ability to demonstrate knowledge and understanding (comprehension and application) of concepts related to simple machines, structure of matter, and equivalent fractions.

The study involved a random sample of 136 ninth-grade physical science students. Each student's proportional reasoning skills were assessed using two Piagetian tasks: The Balance and the Quantifications of Probabilities. The students were classified into four groups according to their proportional reasoning ability. Student achievement of the selected science and mathematics concepts was assessed at the knowledge, comprehension, and application levels using a paper/pencil test.

The relationship between proportional thinking and level of achievement of the selected concepts was analyzed by applying discriminate function analyses. Knowledge and application test items were found to significantly ($p \leq .01$) discriminate between high quantitative proportional reasoners and high and low qualitative proportional reasoners for simple machines. Knowledge and comprehension test items were found to significantly ($p \leq .01$) discriminate between high quantitative proportional reasoners and high and low qualitative proportional reasoners for structure of matter concepts. In both of these cases, the high quantitative proportional reasoners scored significantly higher ($p \leq .01$) than the high and low qualitative proportional reasoners. Low quantitative proportional reasoners significantly outperformed high and low qualitative proportional reasoners on knowledge of the concepts, but scored significantly lower ($p \leq .01$) on application level test items. Application was found to significantly ($p \leq .01$) discriminate between qualitative and quantitative proportional reasoners for the equivalent fractions concepts.

In conclusion, test items which assess achievement of the selected science concepts at the knowledge level can be used to discriminate students' proportional reasoning ability, as do test items written at the comprehension and application levels, demonstrating a positive relationship between students' proportional reasoning ability and their knowledge and understanding of simple machines and structure of matter concepts. Test items which assess achievement of equivalent fractions at the application level can be used to discriminate students' proportional reasoning ability, thus demonstrating a positive relationship between students' proportional reasoning ability and the degree to which they achieve application of equivalent fractions.

ACTUALIZING TEACHING INTENTIONS BY CONCRETE AND FORMAL OPERATIONAL PROSPECTIVE ELEMENTARY SCHOOL TEACHERS IN NIGERIA

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Although Piaget's theory of intellectual development is exerting strong influences on research and theory in science education, the instrumental value and practical implications of the theory especially as it relates to classroom pedagogy has only become a major concern to science educators. Science educators are agreed that the development of the architectonics of formal operational schemata among prospective elementary school teachers (PEST) is an important goal of science teaching, but as of now little or no empirical investigation has been made on how prospective elementary school teachers operationalize these intellectual strategies in the planning and subsequent actualization of their intentions in practical classroom situations.

The present ongoing study investigates the performances of concrete and formal operational PEST on certain teaching tasks. The specific questions asked in the study are whether significant differences exist between concrete and formal operational PEST in their ability to:

1. Plan a hypothetical teaching program (including a diagnosis of learners' major and minor problem areas) of a topic of their choice; i.e., their teaching intentions, and
2. Actualize these intentions in practical classroom teaching situations.

In effect, the study investigates what differences exist between concrete and formal operational strategies and teaching performance.

Eighty randomly selected PEST constitute subjects for the study. Their ages range from 18 to 23 years with a mean age of 20 years. None of the Ss has had teaching experiences but they have taken courses in teaching methods and the psychology of learning.

Six classical Piagetian tasks used in distinguishing between concrete and formal operational individuals are conservation of volume using clay, the elimination of contradictions, controlling variables, combinatorial, proportional and syllogistic reasoning tasks.

The teaching tasks (TT) consist of two phases, Phase I, the intention phase—requires the Ss to prepare a lesson plan including possibilities regarding how the lesson can be effectively taught;

arrangement of a series of instructional materials appropriate for the several grade levels to be taught and a diagnosis of a series of hypothetical and conceptual learners major and minor learning difficulties. Phase II deals with the actualization of already stated intentions. In this phase *Ss* bring into operation their various strategies (concrete or formal) in the execution of their teaching intentions.

Although the study is still under way (to be completed by December 1977), preliminary findings show that a significant relationship ($p \leq .01$) exists between levels of cognitive development and ability of prospective elementary school teachers to identify and provide relevant instructional materials appropriate to the grade levels to be taught. Thus PEST who are concrete operational provide materials that are mostly concrete. They, in contrast to formal operational *Ss*, also provide more and varied materials that capitalize on the multi-sensory approach to learning. Formal operational *Ss*, in their world of hypotheticalness and possibilities chose abstract topics and did very well in the intention phase but were unable to effectively actualize their teaching intentions. Significant implications for science education are expected to be drawn from this study when finally completed.

CONCURRENT SESSION A

Session A-4 Paper Set: Student Behaviors

Presiding: Chris A. Pouler
Prince George's County Public Schools
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Values and Their Relation to Course Selection and Success at the High School Level

Louis J. Visco
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The Conditions Necessary to Develop the Social Reasoning Required to Solve Moral Issues Prevalent in Our Technological Society

June P. Maul
Rutgers University
New Brunswick, NJ 08901

The Relations Among Attitudes Toward Science, Field Dependence-Independence, Intelligence, and Science Grades

Joseph G. Krajkovich
Rutgers University
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VALUES AND THEIR RELATION TO COURSE SELECTION AND SUCCESS AT THE HIGH SCHOOL LEVEL

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All students have values but differ in the degree of importance that is attached to them. Values are viewed as being deterministic in nature, determined by reinforcement of the environmental situation that students encounter. The theoretical foundation is one that centers on the student's ability to adapt to the various course environments to which he is exposed. The priority ordering of values determines the degree of match between student's self-conceptions and what eventually is realized in the classroom. Thus, it is of interest to investigate the interaction between student values and values relevant for certain courses.

The values and value systems of students in three high school courses which have very different content, methodology, and philosophy; Project Physics, Man-Made-World, and Humanities, are examined. The objective is to show how disparities between the value systems of students successfully completing these courses and those perceived by students electing them are related to course selection and academic success.

Eleventh grade students completing Project Physics, Man-Made-World, and Humanities courses completed the Rokeach Value Survey, ranking the terminal and instrumental values in their order of importance to themselves. The value patterns of successful students from this group are used to establish course values. Tenth grade students electing Project Physics, Man-Made-World, and Humanities courses also completed the Rokeach Value Survey, ranking the values in the order they thought a student successfully completing the elected course would emphasize them. This is called the perceived value system. A higher degree of similarity is found between the perceived value systems of students electing a course and those held by students who have successfully completed the course, than with courses not elected. This high degree of similarity permits a determination of student values match scores, by comparing a student's perceived values system with the median values system of successful students in the elected course.

The determination of student values match scores makes it possible to compare them with the academic scores that students obtain in the elected courses. It is found that a positive association exists between the degree of values match and academic grade obtained in the elected course.

It is suggested that the ordering of values takes into account many of the hidden variables that are at work in the classroom environment and that values matching may be used as an educational technique in predicting academic success. Values are seen as dealing primarily with thoughts and feelings being expressed by the order of priorities assigned to them by students, and therefore involve both the cognitive and affective domains.

The emerging concept is one involving a values match continuum. At one end are students whose values are matched closely to those of the elected course. Although in somewhat different styles, most students at this end of the continuum apparently can deal with the course constructively, resulting in success. Students at the other end of the continuum do not seem to be clear about how to relate to the things and individuals making up the elected courses environment in order to achieve success. In this context, values matching is seen as a means of directing students and teachers into situations where the chances of obtaining academic success are improved.

THE CONDITIONS NECESSARY TO DEVELOP THE SOCIAL REASONING REQUIRED TO SOLVE MORAL ISSUES PREVALENT IN OUR TECHNOLOGICAL SOCIETY

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In the technological society currently found in the United States Science is often forced to deal with moral problems and issues rather than purely scientific ones. Thus science education cannot deal only with the developed skills of analysis and reasoning related to pure science. Rather, science education must also work to develop the reasoning processes necessary to deal with social-technological problems. Reasoning in this joint field has been described by Piaget and Kohlberg. The development of the rational powers needed to deal with such issues has been found to relate to experience in both science education and social experiences found in the classroom. The development of the reasoning necessary to deal with such social-scientific issues will depend on the total classroom and school environment rather than on just the written scientific experiences.

In view of this link between experience and cognitive development, the present study examines the development of social (moral) reasoning as a result of student exposure to the social, experiential atmosphere of a school community with intensive education. A group of 250 students in grades nine through twelve are given the Defining Issues Test which examines social reasoning on six moral judgment stories. The groups examined are approximately equated on variables of I.Q., age, S.E.S., and number of males and females. The study examines the relative importance attributed to principled moral reasoning as a function of the number of years of exposure to intensive education which is considered a highly social and experiential atmosphere. The students' perception of the environment is also examined using Moos's Classroom Environment Scale. Level of principled reasoning and perception of the environment are also examined as a function of being in a science or mathematics class as opposed to being in a humanities class.

Preliminary evaluation of the study shows that the number of years of experience in this school community has a significant effect on the level of moral-cognitive reasoning.

THE RELATIONS AMONG ATTITUDES TOWARD SCIENCE, FIELD-DEPENDENCE-INDEPENDENCE, INTELLIGENCE, AND SCIENCE GRADES

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Field-dependence-independence (FDI) has been studied rather extensively and as such has an excellent theoretical base. It is of particular interest in this study since an apparent relationship exists between FDI and career choice. Research has found that field independent (FI) subjects will usually choose careers that involve analytical skills such as engineering, science, mathematics, and accounting. It therefore seemed reasonable that a relationship might exist between FI and a positive science attitude. If so, a person's cognitive style might be a good indicator of his/her science attitude.

Additionally, research involving the relationship between intelligence (as measured by IQ tests) and attitudes toward science, between intelligence and FDI, and between science attitude and science grades, has been paradoxical. It therefore seemed advantageous to examine these areas further.

Two groups of ninth-grade students from a suburban school were chosen for the study. The first group was a random sample of 204 students from three junior high schools; the second group consisted of 47 high-ability students (as determined by participation in an advanced science course). Ninth-grade students were chosen for the study since all the subjects had identical science backgrounds. The group of high-ability students was included to see if relationships that existed within a larger sample also existed within a group of students who are more likely to actually enter an area of science as a career.

Each group was administered the Short Form Test of Academic Aptitude as a measure of intelligence; the Group Embedded Figures Task (GEFT) to determine field-dependence-independence; the Image of Science and Scientists Scale (developed by the author)* as a measure of attitudes toward science; and the Comprehensive Test of Basic Skills to measure aptitude in the areas of reading, mathematics, English, social studies, reference skills, and science. Multiple regression analyses and Pearson correlation were used to analyze the data.

The results of the data were quite interesting. Field-independence proved to be strongly related to IQ (r = .60). When related to science attitude, IQ and field independence showed a strong relationship unless the scores from the science subtest and science grades were controlled for, at which time the field independence, IQ-science attitude relationship was negated.

With respect to the prediction of science grades, both IQ and attitudes toward science made significant contributions.

The results of this study have educational significance in a number of areas. First, the strong correlation between IQ and FDI coupled with the lack of contribution by FDI to the regression equation calls into question the efficacy of the GEFT. Second, the study sheds some light on the nature of the relationship among the variables in the study. Third, the strong correlation between science attitudes and science grades and the fact that this relationship negates the effect of IQ in the regression equation gives support to the importance of this affective area in science education.

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*Validity and reliability demonstrated in a separate paper.

CONCURRENT SESSION B

Session B-1 Paper Set: Research Methodology

Presiding: David L. VanHarlingen
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Methodological Issues in Research: The Need for Improved Instrumentation and Model Building

David L. VanHarlingen
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Criteria for Assessing Correlational Ability

Janey Cheu
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New Brunswick, NJ 08901

Analysis of Class Inclusion Response Identification Types

Jean Sindhikara
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A Study on Proportional Reasoning

Sharon D. Brendzel
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METHODOLOGICAL ISSUES IN RESEARCH: THE NEED FOR IMPROVED INSTRUMENTATION AND MODEL-BUILDING

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Over the past decade, many researchers have begun to probe the model of formal operational thought as proposed by Piaget. In most cases, the basic tool of investigators has been the tasks described in The Growth of Logical Thinking and similar tomes. While Piaget relied heavily on long clinical interviews for his data, the American fascination has been with standardizing and minimizing the time required for administration of the tasks. Of great interest have been attempts to develop a written task of formal operational thought.

In these efforts, two major problems have received insufficient attention. One involves the efficiency or validity of the measuring instruments. The second involves a need for more detailed models of formal thought structures, both as they develop and consolidate, and in their most highly developed state.

First, using the correlations tasks as described by Piaget and Inhelder as an example, it will be demonstrated that the character or value of a task variable may be changed in a number of ways which, on the surface, appear to leave a task of the same logical complexity. However, by changing the task variable from familiar to unfamiliar, from dichotomous to multi-valued, or from neutral to value-laden, one may be changing the susceptibility of the task to seemingly correct formal solutions through the use of concrete operational skills alone. Another paper in this set will present data demonstrating how this enhances the use of certain cognitive strategies and results in very different clinical task performance.

Data from methodological studies of children's reasoning on proportionality tasks, which exemplify the problem, will be presented. For example, a study of 300 ninth grade students who were given tasks identical in format to the commonly used Mr. Tall-Mr. Short task shows that neither the use of familiar versus unfamiliar measuring units, nor the use of linear versus volume ratios affects performance. In this experiment however, the numbers used in the problem result in different task results. Children demonstrate higher cognitive ability when integer, rather than non-integer proportionality factors were used.

Several other tasks commonly described in use in the literature will be discussed as other examples. From an electronics point of view, our instrumentation problem has been that this instrumental "noise" has been large enough to seriously interfere with the "signal" of interest (cognitive level).

The remainder of the paper discusses the need for a more detailed conceptualization of formal thought. If it can be represented in terms of various operations and schema, it needs to be known which schema develop earliest, which depend hierarchically on the development of others, and at what level of development each must be before consolidation takes place.

Of critical importance is the fact that much previous work has assumed equality of tasks and schema. A more carefully defined structure for formal operations is necessary in order to develop accurate, appropriate instruments. Even the presentation of purely theoretical models is appropriate to stimulate investigations.

CRITERIA FOR ASSESSING CORRELATIONAL ABILITY

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Investigations of correlational ability by numerous researchers, one of the eight basic operational schemes in formal reasoning identified by Piaget, have produced wide discrepancies among results. Reports range from the lack of correlational ability in adults (Smedslund, 1963) to correlational ability as one of the earlier acquired formal operational schemes (Martarano, 1974). Using a different task format, Seggie and Endersby (1972), in their correlations assessment tasks requiring adult subjects to make a decision based on the data presented, found that adults possessed the notion of correlations and could apply this concept when provided with an external reference point.

The criterion measures for assessing correlational ability were investigated using two correlational tasks: one directly patterned after Piaget's original problem set involving the correlation between hair color and eye color and the other, a variation of the first task involving the correlation between the win-loss records of two baseball bats. Subjects, 20 ninth-grade males, 20 eleventh-grade males, and 15 college freshmen were individually interviewed for their ability to: 1) classify the data in terms of four possible categories, 2) construct a data deck showing no correlation ($r = 0$), 3) construct a data deck showing perfect correlation ($r = 1$), 4) demonstrate a logical strategy in comparing decks, and 5) successfully comparing the strength of the correlation between two data decks.

Results of the study revealed that Ss in the age group tested did not possess the notion of correlations according to Piaget's formal logical criteria—reasoning in terms of the relationship between confirming and disconfirming cases (the diagonal cells in a 2 x 2 matrix table) and the total number of cases and applying this reasoning strategy in comparison of two sets of data. However, the developmental nature of correlational ability was clearly evidenced in that the older age groups were significantly more successful in constructing decks illustrating perfect correlation and no correlation and recognizing instances as confirming or disconfirming. By college age, 40 percent of the subjects considered the data as a total system but erred in applying this notion correctly.

Analysis of the strategies Ss displayed point out some methodological inadequacies in the criteria used in earlier investigations.

1. The act of deck sorting is a function of task demands. Subjects do not sort decks into the four categories unless they are required to use the data to make a comparison. All Ss when asked to compare decks classified the information into their appropriate categories.

2. *Ss' ability to make r = 0 and r = 1 decks was necessary but not sufficient criteria for correlational ability*. Older subjects were significantly more successful in making such decks but still were unable to compare the strength of the correlation.

3. *Equal distribution of attention over the categories is a criteria of limited significance*. Subjects tend to consider all four categories when examining the data but selectively focused on only some of the categories when making the actual comparison. The strategy most frequently displayed was the comparison of one category to the corresponding category in the other deck. Here all the data may be utilized but the system of making the comparison is only a partial system in that Ss make a two-way comparison rather than a four-way comparison. In some cases the subjects made the correct judgment, but the system was clearly inadequate from a logical standpoint as well as the fact that the Ss did not deal with the data quantitatively and failed to apply probalistic understanding.

4. *Task variables affected the manner in which the Ss approached the problem*. In task II, Ss more frequently introduced extraneous considerations, confounding the intent of the task.

This examination of male high school and college science students' correlational strategy and analysis of criterion measures suggests that understanding the concept of correlation is a notion still undergoing development for the age group tested.

A fuller understanding of the strategies utilized by high school students in their approaches to scientific data may explain some of the difficulties students encounter in science courses.

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ANALYSIS OF CLASS INCLUSION RESPONSE JUSTIFICATION TYPES

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Following the repeated investigations of the structural characteristics of those concrete operations described by Jean Piaget, recent research interest has been directed toward the clarification of the transition mechanisms which lead to the acquisitions of those operations. It has been the object of the present investigation to extend the work of Inhelder, Sinclair and Bovet (Learning and the Development of Cognition) regarding the transition mechanisms of one particular operation, that of class inclusion.

The operation of class inclusion is described by Piaget as occurring as the culmination of the development of classification skills. The mathematical operation of class inclusion may be described as the reversible relation $A + A' = B$ where A and A' are two complementary subclasses of the class B. Class inclusion ability is measured by having the child compare the size of the class (B) with the larger subclass (A). For example, given a set of wooden beads (B) containing brown wooden beads (A) and white wooden beads (A') the child is asked, "Are there more wooden beads or more brown beads here?" (A task of this form will be referred to as the standard class inclusion task.)

Traditionally in American research a correct answer to the standard class inclusion task has been used as a criterion of operational ability. However, analyses of response justifications of correctly answered questions show that these justifications can be categorized into three types, not all of which indicate operational understanding of class inclusion as measured by a series of additional class inclusion tasks different from the standard class inclusion task.

The three response types are named: (1) all-some in which an empirical comparison (based on the physical properties of the objects) of the class with its major subclass is made, (2) addition in which the additive relationship of the subclasses to the class of concrete objects being classified is described, and (3) sets in which the abstract set of objects within the particular classificatory system being discussed is described. These response types appear to be developmental and to be related to ability on the additional class inclusion tasks. From this relationship a theoretical model of development can be described for the transition between pre-operational and operational understanding of class inclusion.

A STUDY ON PROPORTIONAL REASONING

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According to Piaget, proportional reasoning is one aspect of formal thought. Since proportional reasoning is an important part of science and mathematics courses, educational research on proportional reasoning should be of interest to science teachers.

Some current research centers on the way in which proportional reasoning abilities develop, while other research seeks to understand the specific kinds of problems that make proportional reasoning difficult for students. Still other research examines the factors that influence proportional reasoning. Karplus, for example, has developed a proportional reasoning task called "Mr. Tall and Mr. Short." This task was studied in 1976 by comparing it to another proportional reasoning task called "The Recipe." It was found that the task called "Mr. Tall" was much more difficult than "The Recipe" task and that males did significantly better. Maccoby has reported that males perform significantly better in another area; i.e., in visual-spatial relations. Susan Abramowitz has shown that the use of different ratios influences performance. Wason has shown that familiarity of content influences performance on tasks of logical thinking.

In view of these and other related research, my experiment was designed to test three factors that might influence proportional reasoning: familiarity of content, number related difficulties, and spatial content. In addition to determining whether any of these aspects influenced the performance ability of students, task scores were compared to student ability scores as measured by the Differential Aptitude Test (DAT) and the Otis Lennon IQ test. All tasks were also analyzed to determine whether significant sex differences existed.

A number of tasks were administered to 330 students in grade nine at two local high schools. However, the DAT and IQ scores were available for only one school. The tasks given included two sets of ratios: the complex ratio (4/6 = 6/X) and the simple ratio (4/12 = 6/X).

Surprisingly, although there were differences in performance, none of the differences were statistically significant with respect to the test factors except for the number related factor. As expected, the complex ratios had a larger number of failures than the simple ratio. The scores on the tasks administered do correlate at a significant level with all scores on the DAT test and with IQ.

Based upon this research, further investigation of number ratios is desirable. Additionally, in order to better understand the factors on which proportional reasoning is based, a test more discriminating than the DAT must be found because in this sample all of the subtests of the DAT correlated with each other.

CONCURRENT SESSION B

Session B-2 Formal Operational Thinking

Presiding: Livingston S. Schneider
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Math and Logic Skills Exhibited by College Freshman Chemistry Students

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Interaction of Formal Operational Capability with Instructional Feedback Mode

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The Effect of Intensive Instruction in Cue Attendance on Solving Formal Operational Tasks

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MATH AND LOGIC SKILLS EXHIBITED BY COLLEGE FRESHMAN CHEMISTRY STUDENTS

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Introduction

A sample of over 1200 college freshman in Chemistry 101 at Florida State University were tested over a period of two and a half years on selected math and logic skills. The majority of students in the course included chemistry and other science majors, pre-med majors, and science education majors. The instrument used for assessment of the math and logic skills was a 27-item paper and pencil test that is generally completed in about 30 minutes by most students.

Questions that we hoped to answer by developing and using such an instrument with college freshmen taking chemistry were:

1. What logic skills (of the form suggested by Piaget's work) are functional in such a sample?
2. Are basic math calculations a problem for more than just a few students in such a sample?
3. What relationship exists between such math and logic skills and "success" (final grade) in Chemistry 101?
4. What relationship exists between the findings of this study and Piaget's theory of formal operational thought?

The Study

During the summer and academic year of 1975 to 1976 a 29-item math-logic instrument was developed and tested with 564 students in Chemistry 101 at Florida State University. Careful analysis of the test items, including comparisons of difficulty and discrimination indexes, led to some revisions and a reduction of the number of items, to 27. The revised instrument was administered to 371 students in Chemistry 101. Results were similar on most items and the overall discrimination of the items was improved. Two hundred and seventy-four students were again given the test during the Fall of 1977 with some variation in testing procedures.

Analysis of the data showed that more than half of the students had difficulty with many of the 17 items on basic math skills and similar results were obtained on the logic items. Although Piaget's theory of formal operational thinking seems to suggest that post-secondary students should be capable of solving simple problems involving proportions, combinations, chance, correlations, etc., this study found that relatively few science-oriented college students are able to do so.

Although analysis of variance procedures showed significant differences in the math and logic skills of "successful" (A or B) vs "unsuccessful" (D or F) students in Chemistry 101, regression analysis pointed up the fact that only a small part of the success (about 15%) could be attributed to abilities measured by the test. Among other possible interpretations of this finding is the suggestion that a significant portion of the course expectations can be successfully attained by simple memorization and recall. Although much of the content of college chemistry is formal or abstract in nature, students who appear to function at a preformal level can successfully navigate such content *if* the content is dealt with in a way that memorization and recall can be used as coping mechanisms. The extent to which the so-called "learning" is generalizeable, functional, and lasting is, of course, open to question.

INTERACTION OF FORMAL OPERATIONAL CAPABILITY WITH INSTRUCTIONAL FEEDBACK MODE

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Objectives and Rationale

The objectives of this study were:

1. to determine the effects of two instructional feedback modes on the ability of children in the eighth grade to apply proportional reasoning in problem situations,
2. to determine differential aspects of student affective response to each of the feedback modes,
3. to search for evidence of formal operational capability X treatment interactions,
4. to perform the study in the naturalistic classroom environment of junior high school.

The assumed positive value of physical experience, especially contact with real objects in science and mathematics instruction, has played a major role in instructional design in recent years. It is often claimed that such experience is critical in promoting the transition from concrete to formal operational thinking in the Piagetian model. Yet, little is known empirically about the effects of various levels of contact with real objects and how those levels of contact interact with student capability and form student attitudes.

Methodology and Design

The independent variable in this study was feedback mode in a problem solving instructional sequence emphasizing proportional reasoning. The independent variable was set at three levels: verbal-manipulative, verbal-pictorial, and a standard textbook approach control. Major dependent variables were application of proportional reasoning in novel situations and student attitude toward the instructional materials. Formal operational capability was measured prior to the treatments in order to search for interactions with treatments.

The major hypotheses were:

1. that manipulative-based feedback would be superior in both the promotion of proportional reasoning and positive student attitudinal response;

2. that interaction effects would occur such that students with low formal reasoning capability experiencing manipulative feedback would achieve higher proportional reasoning scores and have more positive attitudes toward the instructional experience than similar students experiencing verbal-pictorial feedback; and that students with high formal capability would achieve equally well in both feedback modes.

The experiment was conducted with four intact classes of eighth grade children in a middle-class suburban school district. To enhance validity of the results for a naturalistic setting, intact groups were not disturbed. Two classes received the verbal-manipulative treatment, one class received the verbal-pictorial treatment, and one class continued the textbook—lab treatment of similar content.

Instruments and Data

Student formal operational capability was measured prior to treatment using the Classroom Test of Formal Operations (Lawson, NARST, 1977). Proportional reasoning capability was measured at the end of the three weeks using a Test to Measure the Proportional Reasoning of Junior High Pupils (Rudd, NARST, 1977). A locally produced Likert scale instrument was used to assess student attitude toward the instructional experience.

Results and Conclusions

At the present time, data analysis is underway. Results with appropriate statistical analysis, including corrections for possible inequities in intact groups, will be reported at the Spring meeting.

Lawson, A. E. "The Development and Validation of a Classroom Test of Formal Reasoning." Paper presented at the NARST Annual Meeting, Cincinnati, Ohio, 1977.

Ruud, O. G. "The Construction of an Instrument to Measure Proportional Reasoning Ability of Junior High Pupils." Paper presented at the NARST Annual Meeting, Cincinnati, Ohio, 1977.

THE EFFECT OF INTENSIVE INSTRUCTION IN CUE ATTENDANCE ON SOLVING FORMAL OPERATIONAL TASKS

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This investigator's experience in evaluating the capability of pre-service elementary science methods students to function at the formal operational stage of cognitive development corraborates recently reported research which indicates that the majority of college students lack this ability. A generalization can be drawn from discussions with methods students who were unsuccessful problem solvers: Most think that the probability of success would have been enhanced if they had first taken the time to carefully sort out and identify the relevant details (or variables) embedded in the problem before attempting solution. Research by Salomon and others indicated that intensive instruction in cue attendance (defined as prevailing upon a subject to describe a very difficult level of relevant details potentially useful in resolving a problem) leads to improved capacity for pre-service elementary teachers to identify a larger number of relevant details in future problem solving activities. In addition, these subjects produced more hypotheses of a higher quality and asked more diverse questions. This study investigated the effect of intensive instruction in cue attendance upon the ability of pre-service elementary science methods to solve, in the Piagetian setting, paper-and-pencil reasoning tests which require a combination of combinatorial reasoning, control of variables, and probabilistic and correlational reasoning.

Thirty-four students from two elementary science methods courses were randomly assigned to two groups. The experimental group experienced intensive instruction, while the control group was instructed to procedures for applying the Cloze Reading Test. All subjects were pre- and post-tested. Both tests consisted of two different sets (three problems each) selected from previously validated research. Each problem requires the subject to first respond "yes," "no," or "can't tell," and then explained in writing how he/she arrived at the answer. The problems were scored 1 if the response was at or below the concrete level of thought; 2 if the response was transitional (basically concrete with limited formal characteristics); and 3 if correct formal reasoning was utilized in problem solution. In addition to blind scoring, evidence that responses were consistently scored was provided by applying Kendall's Coefficient of Concordance to randomly selected responses analyzed separately by the investigator and two other persons. This procedure produced a coefficient value of .86. Intensive instruction consisted of showing to class groups, as many times as required, a discrepant event filmloop and requiring the subjects to record 75 relevant details.

ANCOVA was used to compare post-test scores for the two groups, with pre-test scores utilized as the co-variate. ANCOVA indicated that intensively instructed subjects were judged to be more effective in solving the formal operational tasks ($p = .05$).

This finding provides evidence that training college students to become more critical observers relates to developing successful solutions to formal thought problems. It is hypothesized that intensive instruction requires subjects to develop a strategy to systematically identify variables influencing a phenomenon, a skill lacking in students operating at the concrete level. Future research, particularly with transitional students, needs to be conducted to further explore this hypothesized explanation.

CONCURRENT SESSION B

Session B-3 Panel: Learning Theory

Presiding: Marlin L. Languis
Ohio State University
Columbus, OH 43210

Issues Related to Physiological Indices of the Learning Process and Redefinition of Learning Theory

Panel Members: Rosemarie Harter Kraft
University of California
Davis, CA 95616

Marlin L. Languis
Ohio State University
Columbus, OH 43210

Victor Rentel
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ISSUES RELATED TO PHYSIOLOGICAL INDICES OF THE LEARNING PROCESS AND REDEFINITION OF LEARNING THEORY

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and

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Rationale

Recent advances in theory, research and technology related to phycho-physiological dimensions of the learning process raise substantive challenges and issues for educators. The body and brain are necessarily and meaningfully involved in every learning act. Moreover, changes in certain physiological processes are accompanied by changes in parameters of the learning process. The potency of this observed relationship is substantial.

Measurement of physiological events during performance of school learning tasks adds relevant data to investigations of the learning process, thus challenging current levels of inference, assumption and interpretation in educational research.

In the years ahead it appears probable that planned modifications of elements of the educational milieu and of physiological processes in the learner will substantively alter educational outcomes. Opportunities and issues inherent in such manipulation should be considered now.

Physiological Indices of the Learning Process

Measurement of variation of hemispheric brain functioning during learning tasks is accomplished through a cluster of techniques including the EEG (frequency analysis and evoked potential), tachistoscopic, dichotic and dihaptic presentation. These techniques provide approaches to investigate information processing in the brain. Measurement of changes in heart rate and respiration, profusion, and galvanic skin potential provide approaches to investigate other elements in the learning process such as attention, stress and levels of consciousness.

Issues and Concerns Relevant to Science Education

Approaching educational research from this perspective raises concerns related to interdisciplinary research collaboration, specialized skills and competencies and technological sophistication.

Research efforts in psychophysiological dimensions of learning and learning problems are at an early stage. However, a promising cluster of concerns of science educators now appear to be approachable from a new perspective, thus expanding and defining promising arenas of investigation in research, theory development, educational measurement, curricular and instructional innovation, and idiosyncratic qualities of the individual learner. At the same time, issues related to such areas as mind control are clearly raised.

CONCURRENT SESSION B

Session B-4 **Training Session**

Selecting and Applying Multiple Comparison Techniques for Post Hoc Analyses of Data

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Much of the current research in science education involves multiple-level factors and requires the application of post-hoc analysis procedures to identify loci of differences. There are at least six common procedures available for this purpose. Not all of these are equally powerful, applicable or appropriate to a given situation. The purpose of this workshop is to acquaint participants with a variety of multiple comparison techniques, their strengths and weaknesses, and the appropriateness of their application in a given context.

The activities of the session will include an examination of techniques such as Planned Orthogonal Contrasts, Newman-Keuls, and Dunnett's test. A flow chart for selecting appropriate procedures will be presented and participants will interpret results and error terms associated with each technique.

CONCURRENT SESSION C

Session C-1 Attitude Studies

Presiding: Glenn C. Markle
University of Cincinnati
Cincinnati, OH 45221

Attitudes and Knowledge: Results of a Field Test in Cancer Education for Teachers

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and
G. Boyer
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Hershey, PA 17033
and
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Edinboro, PA 16412

The Relationship of the Learning Environment to Student Attitudes Toward Chemistry

Barry L. Manley
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The Effects of an Energy-Environment Simulator Upon Selected Energy-Related Attitudes of Science Students and In-Service Teachers

David L. Dunlop
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ATTITUDES AND KNOWLEDGE: RESULTS OF A FIELD TEST IN CANCER EDUCATION FOR TEACHERS

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and

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Purpose of the Study

The purpose of the program was to provide a specific group, namely, teachers and school nurses, in several regions of Pennsylvania with a new credit program, An Introduction to Cancer Education for School Personnel, through Health Science Education, Penn State University, Continuing Education. Secondly, the authors were interested in identifying effective models to enhance adult learning in and attitudes toward cancer education.

Method

A sequence of two full-day Saturday sessions were held in different regions of Pennsylvania. Inservice teachers and school nurses (N = 115) enrolled for the workshop and were involved in a series of educational experiences as stated in the program objectives.

In order to evaluate the program effects on the participants, a control group was used (Campbell & Stanley, 1963).

All groups were posttested at the conclusion of the workshop. The data were analyzed for both cognitive learning and attitudinal shifts in the area of Cancer Education.

It was also important to evaluate the criterion test reliability. Based on Kuder-Richardson reliability readings, the 30-item criterion referenced test was an above average predictor with a reliability of .67.

Implications

The models used in the study indicated varying effects on overall learning and attitude outcomes.

Cognitive

Results of the field test indicated that Group A scored significantly higher on the posttest than other groups. Group A also showed significant gain scores from pretest to posttest. Group A had all learning cues (pretest, objectives, posttest).

Affective

Embedded into the posttest were five attitudinal questions. Each student responded to the questions on a scale of SA (strongly agree) to SD (strongly disagree). These questions were analyzed to evaluate any change of attitude that might have occurred during the two Saturday sessions. Based on the findings it can be said that significant shifts occurred among the groups on items 1 and 4. Group A experienced greater positive attitudinal variance than any other group.

Continued research is essential and recommended in the area of adult learning in science-related topics. Science educators must continue to lead the way in this endeavor.

THE RELATIONSHIP OF THE LEARNING ENVIRONMENT TO STUDENT ATTITUDES TOWARDS CHEMISTRY

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Pilot research conducted with the Student Opinion Survey in Chemistry indicated that the learning environment was more important in determining student attitudes towards Chemistry than the type of chemistry course (Dailey, 1974 and Heikkinen, 1973). Properties of the learning environment associated with favorable and unfavorable (or neutral) classroom attitudes towards chemistry had not been identified. This study examined the problem of the learning environment as it related to differential affective outcomes and attempted to answer two specific questions. First, were there overall significant differences in the learning environments of classes who scored high (in the fourth quartile or top 25 percent, strong attitudes towards chemistry) and low (in the first quartile or bottom 25 percent, weak or neutral attitudes towards chemistry) on the Student Opinion Survey in Chemistry. Secondly, what was the exact nature of the differences in the classroom learning environments for the two groups (Q_1 and Q_4).

The sample investigated consisted of 80 Interdisciplinary Approaches to Chemistry (IAC) classes selected from a population of IAC classes in the New England area. Two instruments were used to provide data for the study. The Student Opinion Survey in Chemistry (SOSC), a 20-statement Likert-type scale measured student attitude towards chemistry, and a modified version of the Learning Environment Inventory (LEI), an instrument that measured ". . . the student's perceptions of a wide range of instructional and social cues relevant to his own learning," Walberg and Anderson (1972, p. 381). Both instruments were given to the members of the experimental classrooms early in February, 1976. A two-group discriminant analysis was used to test for overall significant differences in the learning environments of the IAC classes scoring in the first and fourth quartiles on the SOSC. Univariate F statistics were used to examine specific differences between the learning environments of the two groups. The class mean on the SOSC and the LEI was used as the unit of analysis.

The Chi square computed for the multivariate analysis was significant and indicated that the overall learning environments (considering all ten LEI scales concurrently) for the two groups (Q_1 and Q_4) were significantly different. Several important and significant differences were found in the learning environments of students scoring in the first as opposed to the fourth quartile on the SOSC. Students who had the most positive attitudes towards chemistry viewed their classes as being significantly less difficult, having a significantly slower rate of progress, a significantly better physical environment, being significantly more goal-directed, and having significantly less favoritism. Finally, the results suggested that the learning environment influenced affective responses and that the teachers' behavior in interpreting the curriculum was considerably more important in determining student attitudes than the IAC curriculum materials themselves.

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____________. "A Study of Factors Influencing Student Attitudes Towards Chemistry." Unpublished doctoral thesis. University of Maryland, 1973.

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THE EFFECTS OF AN ENERGY - ENVIRONMENT SIMULATOR UPON SELECTED ENERGY RELATED ATTITUDES OF SCIENCE STUDENTS AND IN-SERVICE TEACHERS

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During the past several years there has been an increased interest in energy-related topics. This interest is apparent in both the professional journals and in the popular news media. Many science teachers are including energy-related lessons in their curriculum, and the Department of Energy is allocating significant sums of money to help increase the public's awareness of energy-related topics, problems, and possible alternatives available to the consumer.

The purpose of this study was to investigate the energy-related attitudes of several different groups of science students and science teachers both before and after working with an energy-environment simulator for approximately one hour. The simulator used in this study was a portable, analogue computer designed to increase the student's understanding of the relationships which exist among several different variables relating to energy demands and the effect that these demands have upon the resources and the environment.

Several groups of science students and in-service teachers were administered a short Likert-type questionnaire designed to test their attitude toward energy-related problems. The students were then exposed to a brief lecture/demonstration which utilized the "time machine" to focus upon variables such as the world's energy resources, the demands placed upon these resources by the various countries, and the environmental impact of these demands. The class was then subdivided into six groups and each group was given a lap board containing 22 control knobs which permitted student interaction with the computer. The students were then instructed to make what they felt would be appropriate decisions relating to energy use and production. The computer was then activated and several variables such as population growth, personal energy use, and the distribution of natural resources began to interact based upon the decisions made by the students. A digital counter indicated the number of elapsed years, the lights and buzzers served as monitors of the available resources. The simulation terminated when the non-renewable fossil fuels were depleted, and the number of elapsed years indicated the degree to which the class was successful in "running the world."

The results of this study suggested that the energy-environmental simulator was responsible, at least in part, for attitudinal changes in several different groups of science students and in-service teachers.

One significant aspect of this study was to demonstrate the value of using this type of simulator in helping to create an academic environment conducive to the study and discussion of energy-related topics and problems.

CONCURRENT SESSION C

Session C-2 General Research

Presiding:
Lynn W. Glass
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Scientific Concept Learning in Children Subsequent to A-T Instruction: The Effect of Prior Knowledge on Resulting Cognitive Structure

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The Effect of Field-Dependence-Independence and Instructional Sequence on the Achievement of High School Biology Students

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The Learning Environment: Where You Learn Affects What You Learn

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and

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SCIENTIFIC CONCEPT LEARNING IN CHILDREN SUBSEQUENT TO A-T INSTRUCTION: THE EFFECT OF PRIOR KNOWLEDGE ON RESULTING COGNITIVE STRUCTURE

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This study was carried out within the general framework of Joseph D. Novak's A-TESP (Audio-Tutorial Elementary Science Project). The Project teaches scientific concepts to elementary school children and investigates the acquisition of these concepts by the children (Novak 1977; Pines 1977). The theoretical frameworks of the A-TESP are those propounded by David P. Ausubel (1968) and Mauritz Johnson, Jr. (1967, 1977).

Ausubel's focus is on concept and propositional learning. According to him, the most important single factor affecting meaningful learning is what the learner already knows. Consequently, teaching should be directed at the individual learner subsequent to ascertaining what s/he already knows.

The purpose of this investigation was to examine the effect of relevant existing prior knowledge on resulting cognitive structure, subsequent to planned science instruction. Cognitive structure was defined as the individual's conceptual organization of subject matter.

Relevant existing cognitive structure was ascertained prior and subsequent to instruction using a modified Piagetian clinical interview (MPCI) (Pines 1978a). The subjects were 126 first-grade children in the Ithaca, New York School District. The instruction consisted of 24 Level I lessons. One pre- and three post-instructional interviews were administered.

All of the interviews were taped on audio-cassettes and transcribed verbatim. A conceptual propositional analysis (CPA) was then employed to compare interviews (Pines 1978a). The transcripts were transformed into propositional format and the relevant propositions (i.e., those related to the concepts under investigation) were separated from the irrelevant ones. The relevant propositions and episodes (groups of related propositions) from different interviews were then compared.

Clear evidence was found to substantiate the hypothesis that an important relationship exists between prior knowledge and resulting cognitive structure subsequent to instruction; and thus that relevant existing cognitive structure is an important variable effecting learning.

The most compelling evidence for this claim was found in the divergence of initially different cognitive structures subsequent to an identical instructional sequence—instead of the otherwise expected convergence. Convergence was evident only at a very superficial or surface level.

The observed changes in cognitive structure were consistent with Ausubel's theory of meaningful learning. Relevant subsumers in cognitive structure facilitated the learning of new material, whereas misconceptions, if not adequately clarified, tended to inhibit learning (Pines 1978b).

The MPCI, together with a CPA, were found to be useful in assessing and comparing cognitive structures. Single propositions could be categorized, using different category systems; but the total interview of any single child displayed responses which fell into numerous categories no matter which system was used (Pines 1978c).

From a curricular and instructional point of view, the most important finding was that no single curriculum, or inflexible sequence of lessons, can be adequate for a variety of idiosyncratic cognitive structures in first grade students.

Some recommendations include investigation of the preschool environment, the future follow-up of the children investigated in this study, certain necessary revisions in the A-TESP, and the development of finer methodological tools for the collection and analysis of data.

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THE EFFECT OF FIELD-DEPENDENCE-INDEPENDENCE AND INSTRUCTIONAL SEQUENCE ON THE ACHIEVEMENT OF HIGH SCHOOL BIOLOGY STUDENTS

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The primary purpose of this research was to identify a possible interaction between the cognitive style of the students and the instructional sequence of the materials and their combined effect on achievement.

The students were ranked and classified as field-dependent or field-independent on the basis of their performance on the Group Embedded Figures Test. The students were then assigned randomly to one of the following three groups: 1) an experimental group pursuing a deductively-sequenced package of instruction on classical genetics and probability, 2) an experimental group pursuing an inductively-sequenced package of instruction on classical genetics and probability, or 3) a control group pursuing three related units on cell division and chromosomal abnormalities. A measure of general intelligence was obtained for all students, and all students were pretested over the treatment material. The instructional material for all students was of an audio-tutorial, self-paced, mastery format. A comprehensive posttest measured achievement. This pretest-posttest control group design was conducted in the biology classes of six midwestern high schools. All students were in their first semester of high school biology.

The two levels of cognitive style (field-dependence and field-independence) and the three levels of instructional materials (deductive, inductive, and control) were combined factorially in a 2 x 3 design. Descriptive statistics and correlation coefficients were calculated to provide an overview of the data. Two-way analyses of variance and covariance were performed to investigate all possible main effects and interactions. A stepwise multiple regression was performed to determine the predictive powers of IQ and field-dependence-independence on the dependent measure of genetics and probability achievement.

The major conclusions of the study were the following:

1. the individual difference variable of field-dependence-independence had a significant effect upon the criterion measures of posttest score and gain score when the confounding variable of general intelligence was ignored;

2. when the effect of general intelligence was removed by analysis of covariance, the main effect of cognitive style on posttest and gain scores was nonsignificant;

3. the main effect of instructional sequence had a nonsignificant effect upon the level of achievement of the students;

4. cognitive style and instructional sequence interacted in such a way that the field-independent subjects experienced a higher level of achievement with an inductively-sequenced set of materials and the field-dependent subjects experienced a higher level of success with a deductively-sequenced set of materials;

5. field-independent students achieved a higher level of achievement in genetics and probability than field-dependent students regardless of the instructional materials used; and

6. general intelligence accounted for a significant proportion of the posttest achievement and cognitive style added little to the prediction equation.

THE LEARNING ENVIRONMENT: WHERE YOU LEARN AFFECTS WHAT YOU LEARN

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Field trips to parks, school camps, nature centers, and other outdoor enrichment settings are a standard, highly encouraged, science education practice in American education. To date, nearly all attempts to justify this practice have rested on anecdotal plaudits. However, a study by the present authors (Journal of Research in Science Teaching, in press) demonstrated that students unfamiliar with the setting for an outdoor field trip failed to show task-related conceptual learning after a structured environmental science activity, while children familiar with this type of setting showed significant conceptual gains. Both familiar and unfamiliar groups showed similar and significant increases in knowledge of the general setting. This study suggested that the relative novelty of the environment was a critical variable in determining the response of learners to structured learning demands.

The present investigation extends this prior work to provide a more detailed understanding of the interaction of environmental novelty and task learning. A repeated-measures design was employed in which each subject was tested in both a novel and a familiar setting. Acquisition of both task-relevant concepts and knowledge of the general setting was assessed on the same subjects using a pre-test/post-test design in each of two different environmental conditions—a familiar setting in their home communities and the setting at the Chesapeake Bay Center for Environmental Studies. In order to gain additional insight into the effects of environmental novelty on children, observational data of the subjects' non-verbal behaviors during the activity were collected. It was hypothesized that novelty would produce certain behaviors, such as tenseness or exploration, that should be related to the learning of a structured task. Subjects were 63 ten- to twelve-year olds enrolled in a summer ecology program run by the Smithsonian Institution. Subjects were further distinguished as either "Novices" who had never participated in the program before and thus were totally unfamiliar with the setting at the Chesapeake Bay Center, or "Repeaters" who had participated in the program one or more previous summers and had had an opportunity to visit and explore the Chesapeake Bay Center. On the first day of the study, the subjects did a terrestrial ecology activity in their home communities. On the second day, the same subjects did a matched terrestrial ecology activity at the Chesapeake Bay Center.

Novices showed significant conceptual learning in their home community environment, but failed to make significant learning gains in the novel setting of the Chesapeake Bay Center. By contrast, the Repeaters demonstrated significant learning in both their home community environment and the Chesapeake Bay Center setting. The observational data also revealed significant differences between the behavior of the Novices and the Repeaters at the Chesapeake Bay Center.

Thus, two separate studies, using different methodologies, have shown that the relative novelty of the surrounding environment affects the behavior of children and their learning of a structured science activity. The evidence suggests that environmental novelty must be considered when designing out-of-classroom activities or structuring field trip experiences.

CONCURRENT SESSION C

Session C-3 Critique: Cognitive Structure

Presiding: David F. Treagust
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A Comparison of the Effects of Advance Organizers and/or Behavioral Objectives on the Achievement of Disadvantaged Biology Students

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The Effects of Advance Organizers and Behavioral Objectives on the Facilitation of Learning and Retention of a Biology Unit

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and
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Discussant: Joseph D. Novak
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A COMPARISON OF THE EFFECTS OF ADVANCE ORGANIZERS AND/OR BEHAVIORAL OBJECTIVES ON THE ACHIEVEMENT OF DISADVANTAGED BIOLOGY STUDENTS

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The purpose of this research was to continue efforts to establish the most appropriate type of learning materials for disadvantaged, minority students in large urban high schools. Prior work had identified the most effective format (modified audio-tutorial) and system (audio-tutorial) for this population (Kahle, et al, 1976a and Kahle, et al, 1974). In addition, research had shown these students to be overwhelmingly field dependent in their cognitive style and at or below the concrete stage of intellectual development (Douglass, 1976 and Nordland, et al, 1974). Furthermore, there had been indications of increased achievement when learning materials were deductively sequenced and introduced with advance organizers (Kahle and Rastovac, 1976 and Douglass and Kahle, 1977).

The study was designed to assess the effectiveness of advance organizers and behavioral objectives on the achievement of disadvantaged students. For the study two experimental groups were utilized, treatment and control. Equivalency of the groups was established by t-tests comparing their performances on the SCAT verbal and quantitative tests and on a pre-test over the instructional materials. In addition, biographical information was collected on the subjects.

A series of three audio-tutorial units in genetics covering topics in mitosis, meiosis, and chromosomal abnormalities composed the instructional materials. During the course of the six-week experimental period, all subjects received audio tapes, study guides, visual aides, and tests which had been established as appropriate for these learners and as equivalent in content and difficulty by a group of science educators. The learning materials for both the control and the treatment groups were identical except for the different introductions given to the treatment and to the control group. For each unit, the historical review and the treatment materials (advance organizer, behavioral objectives, or both) were approximately equal in length and in difficulty. The reviews and treatments were presented by audio tapes as well as appearing in the study guide. Achievement was measured by formative unit tests, a summative final test, and a summative retention test. All measures were validated and reliabilities were established.

The results indicated a significant difference in achievement in favor of the treatment group when an advance organizer was utilized in the meiosis unit ($t = -1.99$, $df = 1/90$, $p < .05$) and when both an organizer and behavioral objectives were introduced prior to the chromosome abnormalities unit ($t = -1.58$, $df = 1/104$, $p < .1$). However, the use of behavioral objectives alone (mitosis unit) did not produce significant differences in learning. In addition, the treatment group achieved significantly better on the retention test, administered three weeks after the study ($t = -2.22$, $df = 1/71$, $p < .05$). On the basis of these findings, then, the use of an advance organizer prior to an individualized instructional sequence in a self-paced, audio-tutorial learning format was accompanied by gains in achievement and in retention by disadvantaged students. The organizer functioned with these students, previously characterized as concrete operational and as field dependent, to provide the missing conceptual framework for new facts and ideas and to build cognitive bridges between isolated factual information in order to increase meaningful learning and thereby achievement as measured by summative tests.

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THE EFFECTS OF ADVANCE ORGANIZERS AND BEHAVIORAL OBJECTIVES ON THE FACILITATION OF LEARNING AND RETENTION OF A BIOLOGY UNIT

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The purpose of this study was to investigate the effectiveness of advance organizers and behavioral objectives on the facilitation of learning and retention of a tenth grade biology unit when the entering behaviors, mental ability and prior knowledge were considered.

The subjects for this investigation were 103 tenth grade students enrolled in four classes of BSCS Yellow Version Biology. The instructional treatments were randomly assigned to each subject prior to instruction.

One week prior to receiving the instructional treatment an investigator-constructed prior knowledge test was administered to each student to determine his familiarity with the new instructional material. Mental ability (I.Q.) scores from seventh grade testing using the California Test of Mental Maturity were obtained. Scores from these two tests were used to partition the students into high and low groups to analyze for any interaction between the treatments and the entering behaviors.

The four treatments utilized in this investigation were (1) an advance organizer, (2) behavioral objectives, (3) an advance organizer and behavioral objectives, and (4) a historical passage. The historical passage was utilized as a placebo for the control group. The Ss were instructed to carefully read the instructional treatment for ten minutes at the beginning of the first two instructional periods.

After a two-week period of instruction, in which Chapter 29 from the BSCS Yellow Version Biology (1968) was utilized as the instructional material, a 35-item multiple-choice immediate learning test was administered. Long-term retention was determined by use of the same 35-item test eight weeks later. The prior knowledge test and both post-criterion tests were constructed from resource books developed by the Biological Sciences Curriculum Study.

The experimental data collected were analyzed for significant differences between the mean scores of the four treatments and also for interaction between the entering behaviors, prior knowledge and mental ability, using an analysis of variance technique. A correlational analysis was conducted for the variables I.Q., prior knowledge, immediate learning, and long-term retention.

No significant differences were observed at the .05 level of confidence between the four instructional treatments on immediate learning or long-term retention. This indicated that the four instructional treatments were similarly effective in facilitating learning and retention.

Significant differences were observed at the .05 level between the mean scores of the high and low I.Q. and prior knowledge groups in favor of the high group on the immediate learning and long-term retention tests. However, no significant interaction was reported between the two entering behaviors (I.Q. and prior knowledge) and the four instructional treatments as measured by the same post-criterion tests.

The entering behaviors, prior knowledge and mental ability (I.Q.) were identified as factors that could be utilized to indicate the learners potential for integrating new meaningful material into their cognitive structure. Repeated measures ANOVA indicated that achievement was significantly ($p = .05$) enhanced when the immediate learning and long-term retention mean scores were compared.

CONCURRENT SESSION D

Session D-1 Paper Set: Preservice Teacher Education

Presiding: Hans O. Andersen
Indiana University
Bloomington, IN 47401

A Systems Approach to Elementary Science Curriculum Improvement

Hans O. Andersen
A. W. Strickland
Indiana University
Bloomington, IN 47401

Examining the Differential Effects of Three Information Processing Models on Students' Performance in Classifying Vertebrates

Judith Ann Eggins
A. W. Strickland
Margaret M. Clark
Indiana University
Bloomington, IN 47401

An Examination of Spatial Performance by Pre-Service Elementary School Teachers

Dan R. Jones
A. W. Strickland
Indiana University
Bloomington, IN 47401

An Analysis of the Ecological Attitudes and Knowledge of Pre-Service Elementary Teachers by Personality Types

Munawar A. Anees
A. W. Strickland
John R. Staver
Indiana University
Bloomington, IN 47401

Dimensions of Grouped and Individual Performance Using Computer Assisted Instruction in Elementary Science Methods

A. W. Strickland
Indiana University
Bloomington, IN 47401

Analysis of Student Performance in Elementary Science Methods: Examining Personality Type Characteristics and Testing Format

Margaret M. Clark
A. W. Strickland
Indiana University
Bloomington, IN 47401

A SYSTEMS APPROACH TO ELEMENTARY SCIENCE CURRICULUM IMPROVEMENT

Hans O. Andersen
A. W. Strickland
Indiana University
Bloomington, Indiana 47401

The goal of this study was to investigate the vistas of technology, siphoning those which appeared to be useful in the "ARC" model of the elementary science methods course. The task involved two phases. Phase one included identification of methods, machines, media and environments which augment the activity, research and competency components of the model. An analysis of these selections is discussed in this paper.

Phase two involved possible future directions for the "ARC" model and how to best meet the needs of the elementary teacher population. A NSF Planning Grant was developed from this exploration which has envisioned the integration of science courses (Arts and Sciences) and elementary science methods instruction (Education). This plan offers the possibility of making science a more relevant subject to elementary teachers and could have an impact on the quantity and quality of science being taught in elementary schools tomorrow.

EXAMINING THE DIFFERENTIAL EFFECTS OF THREE INFORMATION PROCESSING MODELS ON STUDENTS' PERFORMANCE IN CLASSIFYING VERTEBRATES

Judith Ann Eggins
A. W. Strickland
Margaret Clark
Indiana University
Bloomington, Indiana 47401

A previously mentioned goal of the "ARC" elementary science methods model is to design instructional treatments which focus on the various aptitudes of the learners. The goal for this study was to examine the effect of three information processing models on students of different personality types in their performance of classifying vertebrates.

The information processing models selected for this study were those of Ausubel, Bruner and Gagne. The personality types were defined by the Myers-Briggs Type Indicator (MBTI). One hundred and fifty students were randomly selected and assigned to one of five treatment groups. Subjects were administered the MBTI and a pretest prior to commencement of the vertebrate classification treatments. Posttest measures were designed to assess vertebrate classification performance.

Initially the results were analyzed to examine the relative effectiveness of each information processing model in aiding vertebrate classification performance. Further investigation used the MBTI results with an Aptitude Treatment Interaction (ATI) model, to investigate whether personality types, as defined by the MBTI, reacted more favorably with particular information processing models. Implications for further research in information processing models and individualized instruction are discussed.

AN EXAMINATION OF SPATIAL PERFORMANCE BY PRE-SERVICE ELEMENTARY SCHOOL TEACHERS

Dan R. Jones
A. W. Strickland
Indiana University
Bloomington, Indiana 47401

The purpose of this study was to assess the effect of dimensional instruction on spatial performance of students enrolled in elementary science methods at Indiana University. Specifically, the dimensional instruction involved audio-tape presentation of pictoral material focusing on perspective views of three-dimensional objects.

Sixty students were randomly selected and assigned to treatment groups, one group receiving the audio-tape instruction, the other was a placebo control group. A posttest control group design was utilized with thirty students assigned to each group.

The results indicated that the dimensional instruction was significant in proving spatial training. In addition, the results indicate that further examination of spatial aptitudes among pre-service elementary teachers is needed and could provide insights into teacher training techniques.

AN ANALYSIS OF THE ECOLOGICAL ATTITUDES AND KNOWLEDGE OF PRE-SERVICE ELEMENTARY TEACHERS BY PERSONALITY TYPES

Munawar Ahmed Anees
A. W. Strickland
John R. Staver
Indiana University
Bloomington, Indiana 47401

The purpose of this study was to examine the aptitudes and personality patterns of the elementary pre-service teacher population at Indiana University. Specifically, the affect, actual commitment, verbal commitment, and knowledge as defined by Maloney's (1975) Ecological Attitudes and Knowledge test, and the personality patterns as defined by the Myers-Briggs Type Indicator (MBTI) were assessed for one hundred and ninety-six pre-service elementary teachers enrolled in an elementary science methods course. Findings of the Ecological Attitudes and Knowledge test were compared with earlier results for Indiana pre-service and in-service elementary teachers. Significant differences in personality patterns as defined by the MBTI were also found. Results of the MBTI and Ecological Attitudes and Knowledge test were correlated, and implications of all findings are discussed with respect to existing aptitudes and personality patterns of pre-service elementary teachers, and the design of instructional activities which focus on certain aptitudes and personality traits.

DIMENSIONS OF GROUPED AND INDIVIDUAL PERFORMANCE USING COMPUTER ASSISTED INSTRUCTION IN ELEMENTARY SCIENCE METHODS

A. W. Strickland
Indiana University
Bloomington, Indiana 47401

This paper, and succeeding papers within this paper set, report the preliminary results of various experimental studies conducted in the "ARC" (Activity, Research and Competency) model of the elementary science methods course at Indiana University, Bloomington. The "ARC" model was developed to provide a more complete program for elementary pre-service teachers. The goals of this model are to: (1) encourage more science teaching in the elementary classroom, (2) identify various aptitude and personality parameters of the elementary pre-service teacher population, (3) design instructional treatments which focus on many of these aptitudes, and (4) explore the vistas of technology, siphoning those which appear pedagogically sound.

The purpose of this study was to investigate the relationship between individuals and groups (three students) receiving metric instruction via the PLATO-IV computer, and secondly, to examine metric performance using an Aptitude Treatment Interaction (ATI) model in which the differential effects of impulsivity, reflectivity and personality were surveyed in relation to grouped and non-grouped students. It was expected that treatment conditions (grouped/non-grouped) would influence the metric performance of the elementary pre-service teachers. Furthermore, it was anticipated that learner characteristics would interact significantly with treatment conditions.

One hundred and ninety-six subjects were randomly assigned to one of four treatment groups. Subjects were administered aptitude tests representing impulsivity-repulsivity, the Myers-Briggs Type Indicator (MBTI) and the pretest prior to the treatments via the PLATO-IV computer.

The results indicated that students in groups performed significantly better than the individuals or the control groups. Secondly, an interaction was apparent between impulsivity-reflectivity in various student groupings. In addition, latency and error scores interacted with posttest performance. Thirdly, students having certain personality types performed significantly better than others via the PLATO-IV computer method of instruction.

The results of this study provide evidence concerning the relative contribution of grouping in instructional computer usage. The cost efficiency and the learning implications have potential for future instructional computer research, and the data examined with respect to ATI may prove valuable in performing related investigations.

ANALYSIS OF STUDENT PERFORMANCE IN ELEMENTARY SCIENCE METHODS: EXAMINING PERSONALITY TYPE CHARACTERISTICS AND TESTING FORMAT

Margaret M. Clark
A.W. Strickland
Indiana University
Bloomington, Indiana 47401

One goal of the "ARC" elementary science methods model, as stated in the introductory paper, is to examine various personality parameters which could effect performance. The research reported is focused upon the relationships among selected personality characteristics and success with the preference for differing test formats.

One hundred and ninety-six students in elementary science methods were administered the Myers-Briggs Type Indicator (MBTI) prior to receiving any tests. Performance measures consisted of three test formats: multiple choice, short answer/essay, and multiple choice administered on the PLATO-IV computer. For one examination, each student was evaluated by use of one of the three test formats, as they preferred.

Interactions between personality type characteristics as defined by the MBTI and scores on all four tests, and between personality characteristics and test format preference were analyzed. Implications concerning why certain students outperform their peers on certain evaluation formats are discussed, and a rationale for providing students with options in evaluation formats is constructed.

CONCURRENT SESSION D

Session D-2 Roundtables

Presiding:
Douglas Hue[illegible]el
Dalhousie University
Halifax, Nova Scotia, Canada
B3H 3J5

The Effect of Cue Specificity on Learning of Material in Graphs

Sandra Kirk
University of North Florida
Jacksonville, FL 32216
and
Donald Kauchak
University of Utah
Salt Lake City, UT 84112
and
Paul Eggen
University of North Florida
Jacksonville, FL 32216

The Comparative Effects of Kinetic Structure on Knowledge Acquisition and Affective Response: An Experimental Investigation of Two Biology Sound Motion Picture Films

Ellen S. Simmons
Teachers College
New York, NY 10035

Applications of Pattern Analysis (Macroanalysis) in Classroom Interaction Research

James A. Shymansky
University of Iowa
Iowa City, IA 52242
and
John E. Pennick
University of Iowa
Iowa City, IA 52242

THE EFFECT OF CUE SPECIFICITY ON LEARNING OF MATERIAL IN GRAPHS

Sandra Kirk
Paul Eggen
University of North Florida
Jacksonville, Florida 32216

and

Donald Kauchak
University of Utah
Salt Lake City, Utah

Objectives and Rationale

The objective of the study was to compare the effects of different types of written mathemagenic cues on the acquisition of information from graphs.

Graphs are often used as supplements in science texts but studies have shown that they often add little to understanding (Vernon, 1946; Vernon, 1950) or may even be deleterious (Vernon, 1951). Further research has shown that supplementary questions and objectives can act as aids in learning from prose material (Rothkopf, 1970; Frase, 1970; Duchastel and Merrill, 1973; Faw and Waller, 1976). The effectiveness of the cues was attributed to their ability to induce scanning or searching behaviors in the reader. One study (Kauchak, et al., 1976) found that questions can also increase knowledge-level, recall-type learning from graphs. Kauchak, et al., found that specific cues enhanced the acquisition of specific information but produced little general scanning of the graphs.

The present study extends the earlier investigation to determine if cues in the form of generalizations can produce searching behaviors in readers studying graphs.

Methodology and Design

One hundred fifty-six students were randomly assigned to four experimental treatments. Each group was given packets describing the results of three, two-week experiments on plant growth reported in the form of bar graphs. The Overall Cue group read a written cue in the form of a broad generalization relating to both weeks of the experiment; the General Cue group read a cue in the form of a generalization about the final week of the experiment; the Specific Cue group read a cue in the form of a specific factual question about the results, and the Control group read a placebo. Each group was given the same amount of time to study the materials and were tested immediately after studying each graph.

Instruments and Data

A posttest consisting of 16 items in two subtests was used to measure students' acquisition of information. Recall items measured students' ability to remember information directly related to each type of cue and Incidental items measured the acquisition of information resulting from searching or scanning the graphs. The Kuder-Richardson 21 reliability for the posttest was .94. The data from each subtest as well as total scores were analyzed using analysis of variance and appropriate follow-up procedures.

Results and Conclusions

The results showed that for Total Scores the Specific Cue and General Cue groups scored significantly higher than the Control Group ($p < .0001$). For recall of specific information the Specific Cue group scored higher than all other groups ($p < .001$). On the Incidental subtest the General Cue group scored higher than the Control group ($p < .05$).

The results of the Recall subtest are consistent with earlier research on learning from graphs (Kauchak, et al., 1976) in that the specific cue enhanced the acquisition of specific information but did not produce general searching. However, the General Cue did induce general searching behavior as evidenced by the Incidental subtest results. The study showed that the type of cue does affect the searching behavior of students. The reason for the failure of the Overall Cue to induce searching behaviors is unclear, but perhaps the cue may have been too broad to allow the learner to relate it to the specific information in the graphs.

Further studies are needed to clarify this area.

Duchastel P. and Merrill P. "The Effects of Behavioral Objectives on Learning: A Review of Empirical Studies." Review of Educational Research, 1973, 43, 53-69.

Faw, W. and Waller, T. "Mathemagenic Behaviors." Review of Educational Research, 1976, 46.

Frase, L. "Boundary Conditions for Mathemagenic Behaviors." Review of Educational Research, 1970, 40, 337-347.

Kauchak, D.; Eggen, P.; and Kirk, S. "The Effects of Written Cues on Learning from Graphical Material." Paper presented at annual convention of the National Association for Research in Science Teaching, 1976, San Francisco.

Rothkopf, E. "The Concept of Mathemagenic Activities." Review of Educational Research, 1970, 40, 325-336.

Vernon, M. "Learning from Graphical Material." British Journal of Psychology, 1946, 40, 145-157.

___________. The Visual Presentation of Factual Data." British Journal of Educational Psychology, 1950, 40, 1974-185.

___________. "Learning and Understanding." Quarterly Journal of Experimental Psychology, 1951, 3, 1 and 33.

THE COMPARATIVE EFFECTS OF KINETIC STRUCTURE ON KNOWLEDGE ACQUISITION AND AFFECTIVE RESPONSE: AN EXPERIMENTAL INVESTIGATION OF TWO BIOLOGY SOUND MOTION PICTURE FILMS

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Selecting a good sound motion picture film from a catalogue can be an onerous task for teachers even when a description, grade level, and running time are specified. This is especially true for science teachers because the supply of available films is increasing at a prodigious rate. Today, with the increasing number of innovative curricula in educational institutions, students are often selecting films for themselves from their film library. Which one will be best understood? This is a crucial question for students, educators, and film producers. A possible solution would employ Anderson's theory of kinetic structure and techniques to quantify the degree to which information is communicated. If film producers utilized Anderson's quantitative measures, teachers and students could be invaluably assisted in selecting films that will be understood and enjoyed to the maximum extent possible.

This study was an experimental investigation of the effects of variations in structure on knowledge acquisition and effective response after viewing two films. Two films on the topics of Segmentation and Parasitism were rewritten to yield a high structure and a low structure version. The content of the high structure version was identical to that of the low structure version and only the organization was changed. There were two experimental groups drawn from biology classes in an urban high school. Each group contained 35 subjects who were randomly selected. Each subject experienced the two films: one with low structure and the other with high structure, thus providing a counterbalanced design.

The independent variable in this research was communication structure, and the dependent variables were knowledge acquisition and affective response. According to Anderson's kinetic structure theory, a communication having high structure will facilitate greater knowledge acquisition and produce a more positive affective response than a presentation having low structure.

In the experimental treatment, the subjects viewed a film and were immediately tested using the following measures:

1. Free recall test of knowledge.
2. Affective test to assess student reaction to the film (Butterworth, 1973)
3. Multiple choice knowledge test.

The free recall test required the subjects to write as much of the narrative as they could recall from the film. The affective test assessed five sub-dimensions and yielded six scores (five for the sub-dimensions and one for the total score). The five sub-dimensions were:

I. Awareness of film structure
II. Ease in understanding film
III. Satisfaction in responding to film
IV. Evaluation of film as helpful
V. Attitude toward film.

The multiple choice test consisted of twelve items with four choices each. The test was designed to assess knowledge of selected facts throughout the film and hence provided a more directed measure of knowledge acquisition than obtained with the free recall test. Thus there were eight dependent variables to be assessed for each of the two films, giving sixteen scores to be evaluated.

Sixteen t-tests were performed to determine whether statistically significant differences existed between the two treatment groups. The high structure group exhibited statistically significant higher mean scores than the low structure groups on all measures except the score on sub-dimension V of the affective test for the Segmentation film. The t-values for the Segmentation film were as follows: free recall 17.58, total affective test score 7.38, affective sub-dimensions—I, 6.09; II, 4.09; III, 6.37; IV, 7.23; V, 0.91 (N.S.); and multiple choice 6.60. The t-values for the Parasitism film were the following: free recall 24.39, total affective test score 9.15, affective sub-dimensions—I, 6.68; II, 4.51; III, 5.78; IV, 5.72; V, 5.12; and multiple choice 7.73. All significant t-values were at $p < 0.005$.

These results indicate that high structure film narrations produce greater knowledge acquisition and more favorable affective responses, on the whole, than low structure narrations. Moreover, the low structure version of the films used in this study were comparable in structure to that found in the original films. Hence, it is recommended that those films for high school use exhibiting low kinetic structure can be improved by giving greater attention to the narrative structure of these curriculum devices. In addition, the results of this study give further support to the predictive value of kinetic structure theory.

Butterworth, T. "A Study of the Effects of Lesson Verbal Structure on Aspects of Student Affective Learning in Freshman College Biology." Doctoral dissertation, Teachers College, Columbia University, New York, 1973.

APPLICATIONS OF PATTERN ANALYSIS (MACROANALYSIS) IN CLASSROOM INTERACTION RESEARCH

James A. Shymansky
John E. Penick
University of Iowa
Iowa City, Iowa 52242

Participants will spend the majority of the time examining pattern analysis (MACROanalysis) programs and sample printouts in an effort to familiarize themselves with the capabilities of the system and the program parameters. With this working knowledge of the system and a punched program deck in hand, ready-to-go, the participant will be fully equipped to run a MACROanalysis using their own systematic observational data. A limited time will be devoted to discussion of completed and ongoing research applications of MACROanalytic techniques.

Session D-3 Training Session

Planning and Designing Evaluation Studies

Leader: Wayne W. Welch
University of Minnesota
Minneapolis, MN 55455

Several practical considerations in the planning and design of evaluation studies will be addressed in this session. Key planning concepts to be discussed include program descriptions, evaluation purposes, roles, audiences, and evaluative questions. Examples from actual science education programs will be used to illustrate these concepts.

A menu of evaluation frameworks (models) will be presented, but major emphasis will be placed on a dozen or so evaluation strategies that have evolved in recent years. Examples include such things as adversary teams, case studies, experiments, and goal-free evaluations.

Session D-4 Training Session

Multiple Regression Analysis Techniques in Science Education Research

Leaders: G. W. Moser
P. Rojas
N. Rojas
M. Duffy
G. Ziccarelli
University of Pittsburgh
Pittsburgh, PA 15213

The purpose of the training session is to help science educators use multiple regression techniques and understand the results of treatments. Computer program treatments of study data will be practically presented, in an informal manner designed for your exploring the use of techniques. The techniques will be for coding binary variables, coding designs for partitioning samples, selecting the best subset of sets of independent variables, isolating pre-post test effects, defining disturbances in models, identifying spurious independent variables, developing reasonable extrapolations in forecasts, and determining the aptness of forecast models.

CONCURRENT SESSION E

Session E-1 Symposium: Proportional Reasoning

Presiding: Rita W. Peterson
California State University
Hayward, CA 94542

Proportional Reasoning at the University Level:
Alternative Task Analyses and Teaching Modes

Members: Frank Collea
California State University
Fullerton, CA 92634

Susan Nummendal
California State University
Long Beach, CA 90801

Rita W. Peterson
California State University
Hayward, CA 94542

Eric Streitberger
California State University
Fullerton, CA 92634

PROPORTIONAL REASONING AT THE UNIVERSITY LEVEL: ALTERNATIVE APPROACHES TO TASK ANALYSIS AND TEACHING

Rita W. Peterson
Dr. Frank Collea
Dr. Eric Streitberger
California State University
Fullerton, California 92634

and

Dr. Susan Nummedal
California State University
Long Beach, California 90801

The development of logical reasoning, or formal thought in Piagetian terms, is presumed to take place during adolescence; yet there is evidence that many university students fail to solve problems or tasks in science which require one or more formal thought processes such as proportional reasoning. Recent studies of adolescents' abilities in proportional reasoning have helped to clarify the gradual development of this intellectual process among American and European students (Lunzer and Pumfrey, 1966; Karplus and Peterson, 1970; Karplus, et al., 1974; Kurtz, 1976; Karplus, et al., 1977). The publication of such research, along with the availability of films (Karplus and Peterson, 1976) and training sessions (Collea, et al., 1975; Karplus, et al., 1977), have helped to stimulate interest among university science educators and focus their attention toward the formal reasoning abilities of their science students.

The purpose of this symposium is to present an overview of the status of research and teaching related to one aspect of formal thought: proportional reasoning at the university level. Participants will analyze (via task analyses) the thinking processes required in proportional reasoning. Following a brief discussion of the assessment of proportional reasoning abilities among university students, the participants will compare a number of strategies which have been used to teach proportional reasoning.

The research and teaching discussed by symposium members represent varied views held by professors of physical science and chemistry, and by psychologists and research educators familiar with Piagetian theory.

1. OVERVIEW OF THE STATUS OF RESEARCH AND TEACHING RELATED TO PROPORTIONAL REASONING AT THE UNIVERSITY LEVEL: A discussion of the current efforts of university science educators to assess the logical reasoning abilities of their students, and to analyze their curriculum in terms of proportional reasoning requirements will be presented.

2. TASK ANALYSIS OF PROPORTIONAL REASONING: The intellectual or logical thought processes required to solve science problems or tasks will be analyzed through two contrasting task analyses developed by professors of physical science and Piagetian theorists.

3. ASSESSMENT OF PROPORTIONAL REASONING: Participants will illustrate various techniques used to evaluate the proportional reasoning abilities of university students, and the results of those assessments at one university.

4. STRATEGIES TO TEACH PROPORTIONAL REASONING: Two university professors will discuss their varied approaches at teaching proportional reasoning to students in a physical science course for non-majors.

Collea, F.; R. Karplus; J. Renner; R. Fuller; and L. Pauley. "Physics Teaching and the Development of Reasoning." An American Association of Physics Teachers publication, 1975.

Karplus, R.; E. F. Karplus; M. Formisano; and A. Christian-Paulsen. "A Survey of Proportional Reasoning and Control of Variables in Seven Countries." *Journal of Research in Science Teaching*, *14*, 1977, pp. 411-417.

Karplus, R.; E. F. Karplus; and W. T. Wollman. "Intellectual Development Beyond Elementary School-IV: Ratio, The Influence of Cognitive Style." *School Science and Mathematics*, *74*, 1974, pp. 476-482.

Karplus, R. and R. W. Peterson. "Intellectual Development Beyond Elementary School-II: Ratio, A Survey." *School Science and Mathematics*, *70*, 1970, pp. 813-820.

Karplus, R. and R. Peterson. "Formal Reasoning Patterns." (16mm color film) Davidson Films, Inc., 1976.

Kurtz, B. A. "A Study of Teaching for Proportional Reasoning." Doctoral dissertation, University of California, Berkeley, 1976.

Lunzer, A. E. and P. D. Pumfrey. "Understanding Proportionality." *Mathematics Teaching*, *34*, 1966, pp. 7-12.

CONCURRENT SESSION E

Session E-2 Paper Set: Curriculum Evaluation

Presiding: Jerome L. Ciesla
Florida State University
Tallahassee, FL 32306

An Evaluation of Biology Curricula and Its Implications for the Teaching of Science: Rationale/ Strategy for the Study

Howard H. Osburn
Concordia College
Moorhead, MN 56560

An Evaluation of Biology Curricula and Its Implications for the Teaching of Science: Methodology and Findings

Leslie C. Nieves-Squires
Concordia College
Moorhead, MN 56560

An Evaluation of Biology Curricula and Its Implications for the Teaching of Science: Response to the Findings

E. Daniel McKenna
Concordia College
Moorhead, MN 56560

AN EVALUATION OF BIOLOGY CURRICULA AND ITS IMPLICATIONS FOR THE TEACHING OF SCIENCE: RATIONALE/STRATEGY FOR THE STUDY

Howard H. Osborn
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Introductory science courses frequently have to serve diverse populations—students from music, elementary education, art, business education, along with biology majors and minors. Facing the necessity of redesigning two introductory biology courses, three members of the College biology department were prompted to conduct a needs assessment in order to make the curricular revisions responsive to the diverse needs of its students.

This paper has two objectives:

1. A Model for Needs Assessments. The first section describes the rationale for a departmental examination of its curriculum and briefly describes a 10-page instrument designed to survey students who had graduated from the school and had enrolled in one of the two introductory courses between 1960 and 1977. Sampling techniques are also discussed (N = 582). The primary intent of this section is to outline the generalizeable aspects of the study by which departments in other schools might inquire about their course offerings.

2. Teaching Science in Elementary Schools. The second objective is to inquire directly into the needs of one part of the diverse population—elementary school teachers. While the research design calls for examination of many groups in the sample, this paper focuses on one question: To what extent is one required course in biology preparing teachers to teach the life sciences in elementary school systems? The research project addresses the pressing concern that curricular revisions in the undergraduate teaching of biology be as responsive as possible to the "real life" needs of those who have been teaching the life sciences for a number of years in the public school systems.

AN EVALUATION OF BIOLOGY CURRICULA AND ITS IMPLICATIONS FOR THE TEACHING OF SCIENCE: METHODOLOGY AND FINDINGS

Leslie C. Nieves-Squires
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Moorhead, Minnesota 56560

Describing the use of the instrument created by the biology department and the derivation of conclusions offered to the teacher education personnel, this paper has three objectives:

1. A Model for Conducting Needs Assessments. While the paper addresses larger and more inclusive aspects of research in science curricula, it lays particular emphasis on how the tool was used and how data was analyzed. Keeping in mind that the tool might be somewhat idiosyncratic to one institution/department, the paper addresses the needs for other researchers who might be looking for strategies for conducting instructional research.

2. Use of SAS 76.5 Programming. The paper demonstrates the use of Statistical Analysis System packages and, while it does not attempt to be a primer in SAS, it does highlight statistical applications appropriate for retrospective types of research. Besides the obligatory measures of central tendency, the analysis utilizes a variety of statistical applications such as analysis of variance, including recent modifications of the ANOVA procedures.

3. Findings Relevant to Teachers. Initial analyses of the data have demonstrated that teachers responded proportionately lower to a majority of the items included in the biology survey (.05 or greater utilizing t-tests) than did the non-teacher population. The largest emphasis of this paper is to isolate areas which are statistically significant, explain them as far as it is possible within the parameters of the data, and project findings for which there are warrants for generalization beyond the confines of one institution to others who are put in charge of preparing elementary school teachers.

AN EVALUATION OF BIOLOGY CURRICULA AND ITS IMPLICATIONS FOR THE TEACHING OF SCIENCE: RESPONSE TO THE FINDINGS

E. Daniel McKenna
Concordia College
Moorhead, Minnesota 56560

Coming to college with varying levels of preparation in science and having different needs depending on the grade level they plan to teach, elementary education teachers pose a challenge for science departments—particularly, as in the case of biology, when one course must serve to prepare them to teach the life sciences.

This paper has two objectives:

1. Needs of Public School Teachers. The first section elaborates further the findings of the instructional research project. The intent is to discriminate between those aspects of this science course which have proven useful and those that have not proven to be useful for the teacher of elementary science. The response is prescriptive for the future training of elementary education majors, and, more particularly, for curricular reform in the biology courses offered at this school, but the response also has implications for in-service and continuing education.

2. Critique of Science Education Materials. Secondly, the paper juxtaposes the findings of this particular research project with science education texts/curricula presently used in public schools. The primary purpose of this section is to match the needs demonstrated by the teacher population with what is "in the book," pointing out discrepancies between science education materials and what teachers report to be useful, or not useful, in their classrooms. A subsidiary interest, then, is to show how needs assessments (particularly if conducted by a number of colleges) can have the practical effect of aligning science education materials with the needs of teachers. This last section is prescriptive, therefore, for science education materials in general.

ANNUAL LUNCHEON

Presiding:	Roger G. Olstad
Speaker:	NARST--A Look Ahead Robert E. Yager University of Iowa Iowa City, IA 52242

CONCURRENT SESSION F

Session F-1 NARST Award Paper

Presiding: John T. Wilson
University of Iowa
Iowa City, IA 52242

The outstanding paper given at the 1977 annual meeting will be presented again and discussed.

CONCURRENT SESSION F

Session F-2 General Research

Presiding: Mae T. Lee
Project City Science
New York, NY 10003

Cognitive Preferences: A Validation Study

Euwe van den Berg
Vincent N. Lunetta
University of Iowa
Iowa City, IA 52242
and
Pinchas Tamir
Hebrew University
Jerusalem, Israel

A Research Model for Examining the Acquisition, Use, and Effectiveness of Teaching Skills

James R. Okey
Russell H. Yeany
William R. Capie
University of Georgia
Athens, GA 30602

The Congruence of Stated Research Preferences and Published Research of Science Education Researchers

Joe C. Long
David P. Butts
University of Georgia
Athens, GA 30602
a
David H. May
Whitman College
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COGNITIVE PREFERENCES: A VALIDATION STUDY

Euwe van den Berg
Vincent N. Lunetta
University of Iowa
Iowa City, Iowa

and

Pinchas Tamir
Hebrew University, Jerusalem

Objectives and Rationale

Heath (1964) defined four modes of cognitive preference: Recall (R), Principles (P), Questioning (Q), and Application (A). Since then a number of studies have been done in different countries (Tamir, 1977) which showed the utility of the cognitive preference construct as a student characteristic that can be influenced by instruction. At present the most pressing issue in the study of cognitive preferences in science is construct validity. Recently questions have been raised dealing with the internal consistency and the format of cognitive preference instruments, and the relationships between cognitive activities of students and their cognitive preferences (Brown, 1975).

The present study is the first of a series investigating these questions. Specific objectives of this study were:

1. To replicate and extend a study of cognitive preferences of talented high school students using a different cognitive preference instrument (Lunetta/Tamir, 1977).
2. To explore the pervasiveness of the Principles and Application modes across different science disciplines.
3. To investigate the reasons students give when they are asked to explain their responses to a cognitive preference inventory.
4. To pilot some ideas for the study of the relationships between cognitive preferences and cognitive activities of students (asking questions, reporting information, etc.).

Methodology and Design

The Science Cognitive Preference Inventory and an extensive background questionnaire were administered to 144 high school students from throughout the United States who were enrolled in various summer science programs for talented students. After six weeks the SCPI was administered again to some of these students. Forty other students were asked to respond to the SCPI and to explain their responses, which were classified according to empirical criteria by trained raters.

The SCPI assesses cognitive preferences in biological and physical science. Cronbach Alpha and test-retest reliabilities in this study were respectively: Recall .84/.73, Principles .51/.52, Questioning .87/.74, Application .58/.56.

Results and Conclusions

High scores were found for P and Q and low scores for R, which indicates a high level of intellectual curiosity, a critical attitude toward scientific information, and a tendency to generalize findings into relationships and theories, rather than memorizing them.

Comparison of R, P, Q, and A scores for physical science and for biological science showed that the R and Q modes are fairly consistent across disciplines but that the P and A modes are not.

The reasons students reported for their responses to the SCPI lent empirical support to the validity of the testing format for cognitive preference instruments, and raised new questions to be investigated as well.

The pilot study of the relationship between cognitive preferences and cognitive activities of students generated a host of ideas for an extensive study currently being conducted with ninth and tenth grade students. Among others the authors of this paper are looking at the influence of cognitive preferences on the students' reporting and abstracting of information, the construction of test items and the formulation of questions by students.

Significant correlations of cognitive preferences with background factors and attitudes were found.

This study provided evidence for the validity of the cognitive preference construct and raised a number of new interesting questions that are now being investigated.

Brown, S. A. "Cognitive Preferences in Science: Their Nature and Analysis." Studies in Science Education, 1975, 2, 43-65.

Heath, R. W. "Curriculum, Cognition, and Educational Measurement." Educational and Psychological Measurement, 1964, 24, 239-253.

Lunetta, V. N. and Tamir, P. "Cognitive Preferences in Biology of Students Participating in a Secondary Science Training Summer Program." Journal of Research in Science Teaching, 1977, in press.

Tamir, P. "A Note on Cognitive Preferences in Science." Studies in Science Education, 1977, 4, 111-121.

A RESEARCH MODEL FOR EXAMINING THE ACQUISITION, USE, AND EFFECTIVENESS OF TEACHING SKILLS

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Background and Purpose

There are two common types of research studies conducted on teaching skills—one type is concerned with acquiring skills and the other is concerned with the effectiveness of skills when they are used. An example of the first type would be a study of the ability of teachers to learn to ask high level questions. An example of the second type would be a study of the influence of verbal feedback on student achievement.

Investigators often concentrate on either skill acquisition or skill effectiveness studies, but there is a need to merge our research so that we conduct both types of studies in the same context. This will allow studies of the relationships between such variables as the kind of training a teacher receives or their level of skill and the degree to which the teachers can use the skills to influence student outcomes. The purpose of this paper is to describe a plan that incorporates studies of teaching skill acquisition and effectiveness in a coherent two-phase research model (see Figure 1).

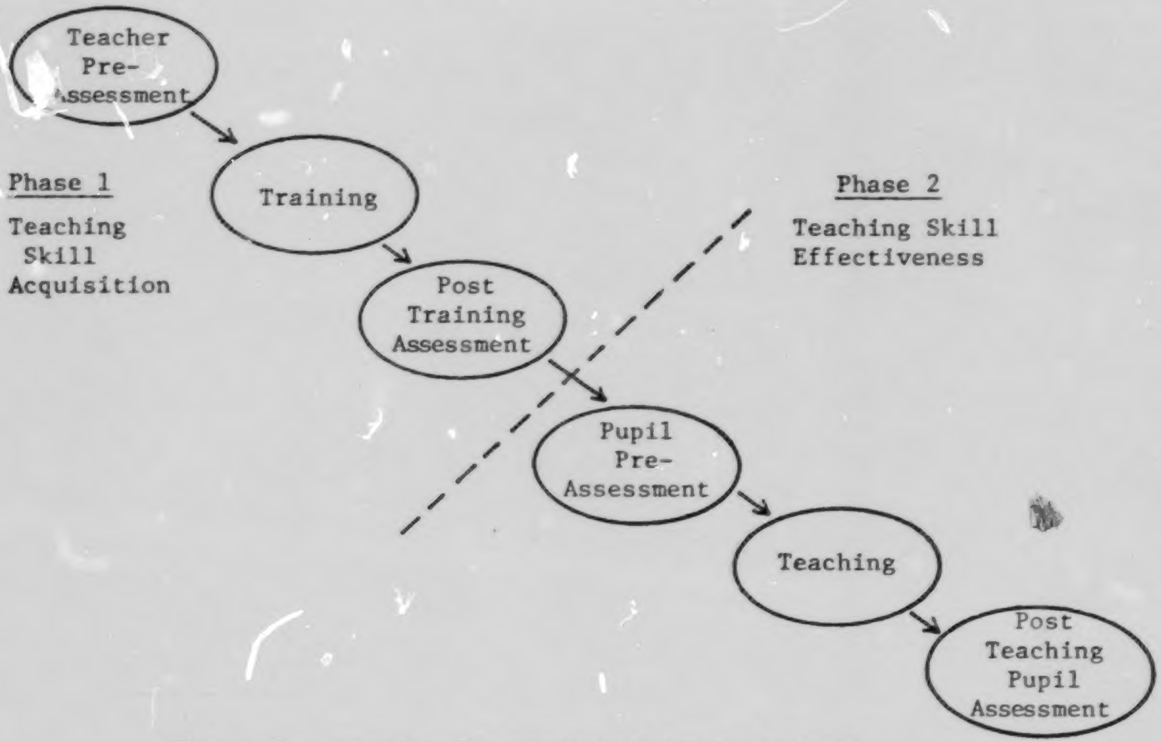
Teacher Pre-Assessment
Phase 1
Teaching Skill Acquisition
Training
Phase 2
Teaching Skill Effectiveness
Post Training Assessment
Pupil Pre-Assessment
Teaching
Post Teaching Pupil Assessment

Figure 1. A model for teaching skills research.

]

Methods

There are three components in each phase of the research model that deal with pre-measures, transactions, and outcomes. For the skill acquisition phase these components are:

> teacher pre-assessment -- measures of teachers such as ability, prior knowledge of the skill, aptitude, or any other variable that may help in the analysis, prediction, or explanation of training results.
>
> training -- the amount and kind of training teachers receive can be systematically varied to see if skill acquisition is affected.
>
> post-training assessment -- any suitable measure of the degree to which teachers acquire skills can be made here. Paper and pencil tests, teacher observation scale scores, or frequency counts of teacher behavior are among the kinds of measures used. Some measures of teacher outcomes may be made in classrooms (e.g., ability to provide verbal feedback) but others may not (e.g., the skill of writing precise objectives).

By varying training conditions and collecting suitable pre- and post assessment data one can answer questions such as:

1. What pre-assessment variables are the best predictors of training success?
2. What variations in training are most effective in influencing the acquisition of teaching skills?
3. Are there interactions between certain personological variables and methods of teacher training?

The components associated with the skill effectiveness phase of the model in which teachers use skills they have learned in classrooms include:

> pupil pre-assessment -- measures of pupils such as prior knowledge, aptitude, level of motivation, or any other variable that may help in the analysis, prediction, or explanation of teaching effectiveness as measured by pupil outcomes.
>
> teaching -- measures of the level of skill use by teachers as they interact with pupils. The levels may be specified in experimental studies or result from natural variations in skill use across a group of teachers in correlational studies.
>
> post teaching pupil assessment -- any measures of pupils used as dependent variables in studies where teaching skills are applied. The particular measures depend on the teaching skills of interest and may range from scores on cognitive tests to frequency counts of pupil activities.

By selecting suitable pre- and post teaching assessment data and with appropriate variations and measures of teaching it is possible to answer questions such as:

1. Are there interactions of pupil variables and levels of teaching skill use that result in effective and ineffective learning?

2. Are there relationships between the amount and kind of teaching skill used and the amount of pupil learning that results?

3. What levels of teaching skill use are compatible with students of different kinds?

The two sets of questions just posed relate to studies within either Phase 1 or Phase 2 of the research model. But a strength of the model is that it shows how to follow teaching skills across the gap from training research to teacher effectiveness research when the teaching skills (dependent variables) from Phase 1 become the independent variables in Phase 2. When this is done it is possible to consider a new set of questions that link training variables to teaching effectiveness outcomes. Questions such as these can be considered:

1. What training conditions are associated with maximum student achievement?

2. What types of teacher training lead to the effective use of teaching skills in classrooms?

3. Are these interactions between teacher and pupil personalogical variables that lead to variations in student achievement?

Educational Importance

The purpose of a research model is to aid in conceptualizing, planning, and conducting research. The model described here serves each of those purposes by helping to identify variables in research on teaching skills, by helping to identify measures to be taken before, during, and after training and teaching, and by helping researchers identify potential relationships among the variables they study.

THE CONGRUENCE OF STATED RESEARCH PREFERENCES AND PUBLISHED RESEARCH OF SCIENCE EDUCATION RESEARCHERS

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Two procedures may be used to establish priorities for the various research areas in science education. One technique would ask researchers to state their preferences. Another way of expressing priorities is through reported research. The relationship between stated preferences and published research illustrates a translation of goals into action.

An investigation using the Delphi Technique was recently performed to determine the research preferences of members of the National Association for Research in Science Education (Butts, et al., 1978). Using the research categories established and the priorities assigned to each in that study, this study investigated the following questions:

1. Are the stated research preferences established in the priorities study congruent with the actual research priorities expressed in published articles?
2. What trends are discernable in research areas receiving publication in the volumes studied?
3. What research areas given a high priority in the priorities study have not received commensurate priority in published research?

In this study, articles published in the Journal of Research in Science Teaching, Volumes 11, 12, and Issues 1-4 of Volume 13, were categorized by area of research.

Study data indicate that a congruence does exist between priorities established using stated preferences and reported research. This congruence is particularly observable in Volume 13. A trend towards change in emphasis of research areas receiving publication was also observed. The three volumes studied varied in the percentage of articles published which were categorized as high priority by the priorities study. Not all research areas assigned a high priority have received published attention. Some priority areas have not had a related article published in any of the three journal volumes examined.

Butts, D., et al. "Priorities For Research in Science Education." Journal of Research in Science Teaching, 1978, 15. (in press)

CONCURRENT SESSION F

Session F-3 Roundtables

Presiding: Michael Szabo
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The Relationships of Student Anxiety and Dependency to the Effects of Teaching Structure on the Learning of Science Knowledge and Processes Within Inductive Discovery Learning

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Differential Effects of Science Study Questions

William G. Holliday
Harold G. Whitaker
K. D. Loose
University of Calgary
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Development and Construct Validation of a Group Administered Test of Piaget's Formal Operational Period

John R. Staver
Dorothy L. Gabel
Indiana University
Bloomington, IN 47401

THE RELATIONSHIPS OF STUDENT ANXIETY AND DEPENDENCY TO THE EFFECTS OF TEACHING STRUCTURE ON THE LEARNING OF SCIENCE KNOWLEDGE AND PROCESSES WITHIN INDUCTIVE/DISCOVERY LEARNING

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Researchers are becoming more amenable to the notion of aptitude-treatment-interaction (ATI) as opposed to the search for the one "best" method of instructional treatment. This study was designed to determine the relationships or student anxiety and dependency to the effects of teaching structure on the acquisition of science knowledge and processes within inductive/discovery learning.

Five correlational concepts from within the conceptual scheme—force—constituted the science content of the instructional tasks. Worksheets were used to vary teaching structure within each of five instructional periods (one task/period). Teaching structure refers to the relative amounts of teacher and/or student control within the tasks. The treatments were developed from existing laboratory procedures. Knowledge and processes level criteria were used to measure the effects of teaching structure. Knowledge level criteria included one post-test for each concept and the composite of the five posttests. Process measures included inferring, predicting, interpreting data, and identifying and controlling variables and the composite of the four scales. The range of KR20 values was .55 to .91 for the knowledge and process measures.

The population was comprised of all fifth and sixth grade students from two elementary schools within one suburban school district. The sample (168) was stratified on scores from the Children's Manifest Anxiety Scale and the Modified Dependence Proneness Scale and the students randomly assigned to the six treatment groups. A pretest analysis showed that the use of the Ankney-Joyce Reasoning Test scores as a covariate reduced personality group differences in knowledge and process level concept understanding which existed prior to treatment.

The data were analyzed using multivariate analysis of covariance. A significant multivariate first order interaction resulted between the treatments and anxiety with the five knowledge level posttests. Significant univariate first order interactions resulted between: (1) the treatments and anxiety with the knowledge posttest for Task 1 (Height Affects Impact Force); (2) the treatments and dependency with the knowledge and process total measures and the identifying and controlling variables subscale; and (3) anxiety and dependency with the knowledge and process total measures, knowledge posttest for Task 2 (Weight Affects Speed), and the process subscales of inferring and identifying and controlling variables. Significant main effects resulted between:

(1) levels of teaching structure with the knowledge posttest for Task 3 (Mass Affects Motion); and (2) levels of dependency with the knowledge posttest for Task 4 (Mass Affects Momentum).

The results support the following conclusions relative to the population sampled in this study.

1. The high anxiety individuals gain more knowledge when teaching is highly structured.

2. The literature and this study are contradictory for the influence of teaching structure on the learning of knowledge by individuals of high anxiety versus low anxiety. In this study, low teaching structure enhanced low anxiety students' performance relative to that of the high anxiety students. The literature suggested the opposite.

3. There is some evidence that low dependent individuals perform better with low teaching structure.

4. The person who is both high in anxiety and high in dependency does better on both the knowledge and process levels of achievement.

5. Overall, low dependency individuals do better on more complex tasks.

6. Overall, a high degree of teaching structure is better for difficult tasks.

DIFFERENTIAL EFFECTS OF SCIENCE STUDY QUESTIONS

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The purpose of this study was to investigate the differential negative effects on "low" and "high" verbal students of verbatim study questions adjunct to a science text. Such easy-to-develop questions are more commonly given by teachers to low verbal students because these learners are often perceived as being unable to answer "higher-order" questions.

The present study was part of a visual-verbal series of aptitude treatment interaction (ATI) investigations in science education dealing with instructional questions rather than mathemagenic questions (as distinguished by Rothkopf). Here, ATI research was concerned with identifying a learner characteristic (verbal ability) indicative of optimal instructional methods (adjunct verbatim or no questions) in terms of school achievement (visual concept attainment).

Previous studies generally suggest that varying types of questions differentially affect achievement. However, critical analyses indicate that research results to date are inconsistent. In part, few investigators use operationally definable study and criterion questions which require the semantic encoding of school-relevant information.

It was hypothesized (ATI-ordinal interaction) that students who are low verbal performers and who are given a science text will outperform those students who are also low verbal performers and who are given the same text with adjunct verbatim questions. Students who are high verbal performers will not be differentially affected by either instructional treatment. Of secondary importance, students given the text and questions will substantially outperform the control group.

The sample consisted of 217 eighth grade earth science students enrolled in the Calgary (Alberta, Canada) public schools. These students were administered a verbal ability test (V-2 Test from the Kit of Reference Tests for Cognitive Factors by French, Ekstrom & Price, ETS, 1965) and then randomly assigned to: 1) a text plus 20 questions; 2) a text plus no questions; or 3) a placebo text (control). The text verbally described the appearance of five fossil types (ammonites, brachiopods, gastropods, pelecypods and trilobites). The study questions consisted of incomplete verbatim statements extracted from the text. The appropriate fossil name was originally integrated into each of these textual statements while two other key or substantive words were later deleted in a definable fashion. Students were asked to fill-in those words deleted from each statement. Subsequently, all students were administered a visual concept posttest requiring them to identify 40 fossil specimens (8 actual fossils from each of the five fossil categories were presented in a random order). The use of this visual test increased the likelihood that verbal information (semantically encoded) was being measured in a manner consistent with good classroom practice.

As predicted, linear regression analysis, using the V-2 Test scores (predictive variable) and the posttest scores (dependent variable), substantiated the ATI-ordinal interaction hypothesis, $F = 8.14$, $DF = 2/135$, $p < .01$. In addition, the text-plus-20-questions group ($\overline{M} = 27$) substantially outperformed the control group ($M = 10$).

Results of this study suggested that verbatim study questions adjunct to a science text constituted a dysfunctional instructional support system, particularly when given to lower verbal students. In contrast, higher verbal students circumvented or were unaffected by such questions.

DEVELOPMENT AND CONSTRUCT VALIDATION OF A GROUP ADMINISTERED TEST OF PIAGET'S FORMAL OPERATIONAL PERIOD

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The goal of this study was to develop and construct validate a group administered test of Piaget's formal operational period in which cognitive decisions and reasons for such decisions are evaluated in an objective format. The format of the group test is forced multiple choice. The test contains four different scales, conservation of volume by liquid displacement, combinatorial analysis, proportional thought, and separation and control of variables. The test is designed for administration to classroom size groups (30 students). Each major problem or task is demonstrated by means of video tape to control for variation in administration procedures.

Two hundred and forty ninth to twelfth grade subjects were randomly divided into three groups of 80 students such that each group contained 20 students from each grade. The content validity of the group test was evaluated by the submission of all test demonstrations and questions to a three-member panel of experts in the area of formal operations. The reliability and construct validity of the group test was evaluated by the Campbell and Fiske (1959) multitrait-multimethod matrix model. The traits assessed were the aspects of formal and late concrete thought described earlier, and the methods employed were the clinical interview, the group test, and the mental ability (IQ) test. The three subject groups formed a posttest-only control group design (Campbell and Stanley, 1963) to control for and evaluate subject learning effects during the validation procedure, and to evaluate the construct validity of the group test. For purposes of this study, clinical tasks were considered to be treatment, and the group test was considered to be the posttest. Findings and implications for science teaching are discussed.

Campbell, D. and Stanley, J. Experimental and Quasi-Experimental Designs for Research. Chicago: Rand McNally, 1963.

CONCURRENT SESSION F

Session F-4 Training Session

Assessing Formal Thinking

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and
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Individual student interviews, group demonstration tasks, and group pencil-paper test items will be compared, contrasted and evaluated as methods of assessing the development of various aspects of formal thought. Their usefulness will be discussed in terms of ease of administration, reliability, and validity. Current research using such methods will be discussed in terms of experimental methodology and possible educational implications. Participants will learn how to use available methods and how to design and evaluate tasks of their own. Use of such tasks in terms of future research will be discussed.

CONCURRENT SESSION G

Session G-1 Cognitive Development

Presiding: John W. Renner
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A Study of a Possible Relationship Between Lowenfeld's Visual-Haptic Theory and Piaget's Developmental Theory

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and
Richard M. Schlenker
Marine Maritime Academy
Castine, ME 04421

The Relationship of Moral and Cognitive Development in Two Cultures and the Implications for Science Teaching

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Gary, IN 46408
and
Mohammed A. Kistha
Governors State University
Park Forest, IL 60400

Application and Analysis of an Electronic Equivalent of Piaget's First Chemical Experiment

Frederick P. DeLuca
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A STUDY OF A POSSIBLE RELATIONSHIP BETWEEN LOWENFELD'S VISUAL-HAPTIC THEORY AND PIAGET'S DEVELOPMENTAL THEORY

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Statement of the Problem

This study was designed to determine the relationship between the Lowenfeldian visual-haptic (perceptual) and the Piagetian concrete-formal (operational reasoning) continua. The study also investigated the relationship between age, sex, academic goal, and academic preference and a person's perceptual aptitude or intellectual reasoning abilities.

Procedures

The study involved the administration of three instruments to a combined sample of 312 students from the University of Maine, Orono, Maine; Husson College, Bangor, Maine; Maine Maritime Academy, Castine, Maine; Norwich University, Northfield, Vermont; and Drake University, Des Moines, Iowa between September 1976 and January 1977. The instruments were: a questionnaire to collect age, sex, academic goal, and academic preference information on each subject; Longeot's (1962, 1965) Piagetian Classification Test to measure the subject's location on the concrete-formal continuum; and Lowenfeld's (Gibson, 1947) Successive Perception Test to measure the subject's location on the visual-haptic continuum.

Methods of Data Analysis

All of the data were manipulated according to the procedures set forth in Statistical Package for the Social Sciences (Nie, *et al.*, 1975).

The relationship between the visual-haptic and the concrete-formal continua was evaluated using a Pearson Product Moment Correlation, a scatter diagram, the eta statistic, the polynomial trends option of the regression analysis technique, and the segregation of subjects into concrete-haptic, concrete-visual, formal-haptic, and formal-visual cells based upon their Successive Perception Test and Piagetian Classification Test scores.

Fisher's F-tests were used to evaluate the relationships between sex, academic goal, and academic preference and an individual's position on either the visual-haptic or the concrete-formal continuum.

Research Questions and Findings

1. Is there a relationship between an individual's position on the visual-haptic continuum and his position on the concrete-formal continuum?

A Pearson r of .34 ($r^2 = .11$, $p \leq .00001$) was obtained when Successive Perception Test scores were compared with Piagetian Classification Test scores. A scatter diagram of the relationship, however, suggested it to be curvilinear. Curvilinearity was confirmed by comparing the eta^2 (.22) value for the relationship ($eta = .47$ with the Piagetian Classification Test as the dependent variable) with the r^2 derived from the Pearsonian r ($eta^2 \neq r^2$). The eta^2 value attributed 22 percent of the intellectual level variation to perceptual aptitude.

2. Do subjects segregate as, (a) concrete-haptic, (b) concrete-formal, (c) formal-haptic, (d) formal-visual?

Subjects were found to segregate into these categories when divided at the mean Successive Perception Test score (17.9) and the mean Piagetian Classification Test score (19.7). The segregation was as follows: (a) concrete-haptic, 26%, (b) concrete-visual, 16%, (c) formal-haptic, 23%, (d) formal-visual, 35%.

3. Is there an equation which will allow prediction of intellectual level based upon perceptual aptitude?

A stepwise multiple regression analysis was run using the polynominal trends option (Piagetian Classification Test scores were used as the dependent variable) to produce a predictor equation based upon a line which best fit the data. The regression analysis used the first, second, third, and fourth powers of perceptual aptitude as independent variables. The equation derived from this technique was: intellectual level $= -31.04 + 5.17$ (perceptual aptitude) $= (-.19)^2$ (perceptual aptitude)$^2 + (.002)^3$ (perceptual aptitude)^3. This equation had a standard error of 1.91, and attributed 83 percent of the intellectual level variance to perceptual aptitude.

4. Does the Piagetian Classification Test scale?

The instrument formed a hierarchical scale in which all of the formal level items except item number 20 were more difficult than all of the concrete level items. Item number 20 was found to be less difficult than concrete level items numbers 5, 14 and 22.

Finally, the reliabilities for the Successive Perception Test and Piagetian Classification Test were .62 and .859, respectively.

Gibson, J. J. Motion Picture Testing and Research. Report No. 7 Army Air Forces Aviation Psychology Program Research Report. Washington, D.C.: U.S. Government Printing Office, 1947.

Longeot, F. "Un Essai d'Application de la Psychologie Genetique a la Psychologie Differentielle." Bulletin de l'Institut National D'Etude, 1962, 18, 153-162.

Longeot, F. "Analyses Statistique de Trois Test Genetiques Collectifs." Bulletin de l'Institut National D'Etude, 1965, 20, 219-237.

Nie, N. H.; Hull, C. H.; Jenkins, J. G.; Steinbrenner, K.; and Bent, D. H. Statistical Package for the Social Sciences. New York: McGraw-Hill Book Company, 1975.

THE RELATIONSHIP OF MORAL AND COGNITIVE DEVELOPMENT IN TWO CULTURES AND THE IMPLICATIONS FOR SCIENCE TEACHING

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Science educators have been encouraged to focus on science and its relations to the affairs of man (Hurd, 1970), and to teach moral values through science (Fox, 1973). However, science curricula have been structured to promote the cognitive growth of students. In order to focus on science-related social issues and to effectively teach moral values through science, the science educator needs to examine the relationship of cognitive skills and moral reasoning skills.

The purpose of this study was to examine possible relationships between moral and cognitive development in second and fifth grade children in two cultures. This relationship was first proposed by Piaget (1932) and later empirically verified and expanded by Kohlberg (1968, 1971). The cultures examined were located in the United States and in Amman Jordan.

Sixty subjects, male and female, were randomly identified from two grade levels—the second and the fifth—in an elementary school in Iowa and in Jordan. The elementary school in Jordan was private, and the elementary school subjects in Iowa attended a public school. The average age difference of second grade subjects between the two cultures was 0.04 years. At the fifth grade level the average age difference between cultures was 0.34 years.

Cognitive and moral judgment tasks were administered individually and in a random order to each subject in a small room in each school attended. Four tasks of each type were administered over a period of approximately six weeks. The cognitive tasks measured conservation, class inclusion, multiplicative classification, and spatial perception. The moral judgment tasks presented situations related to reciprocity, values, and perspective of viewpoints. A level of development, cognitive or moral, was assigned based on the performance of each subject on each task.

The following relationships were examined based on the task responses: 1) the relationship of cognitive development between second and fifth grade subjects within each culture and between the cultures; 2) the relationship of moral development between second and fifth grade subjects within each culture and between the cultures; and 3) the relationship of moral and cognitive development within and between the cultures.

Significant difference at the 0.05, 0.01 and 0.001 levels using the chi-square statistic were reported for relationships examined. The results of the study support to a degree the parallelism of moral and cognitive development reported by Piaget and Kohlberg. Further, the results of the study reflect the influence of the cultures on the cognitive component of growth and on the moral reasoning skills.

Fox, F. W. "After Concept and Process." The Science Teacher, 1973, 40 (4), 19-20.

Hurd, P. "Scientific Enlightment for an Age of Science." The Science Teacher, 1970, 37 (1), 13-15.

Kohlberg, L. "The Child as Moral Philosopher." Psychology Today, 1968, 2, 25-30.

____________. "From Is to Ought: How to Commit the Naturalistic Fallacy and Get Away With It in the Study of Moral Development." In T. Mischel (ed.), Cognitive Development and Epistemology. New York: Academic Press, 1971.

Piaget, J. The Moral Judgment of the Child. New York: The Free Press, 1965. (Originally published —London: Routledge and Kegan, 1932.)

APPLICATION AND ANALYSIS OF AN ELECTRONIC EQUIVALENT OF PIAGET'S FIRST CHEMICAL EXPERIMENT

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Two independent studies showed that Piaget's first chemical task, a test of combinatorial reasoning, can be transformed into an electronic equivalent.

Objectives and Rationale

The purpose of this study was threefold: 1) to assess the usefulness of the electronic task over a broad range of student ages and intellectual abilities; 2) to determine whether the electronic task is a single or double task; and 3) to analyze search-for-combinations patterns of successful and unsuccessful students. If the nature of the electronic task could be clearly understood, test results would be more meaningful, and the task would be a more useful research tool.

Methodology

The electronic task was one of six Piagetian tasks which were used to establish the total Piagetian level of each student and to provide a basis for measurement of student motivation for each task. The battery of Piagetian tasks was administered, by three trained examiners, to a stratified random sample of 384 (198 males and 186 females) students in grades 4 through 12.

Results

Analysis of variance of the electronic task scores yielded a significant ($F_{9,342} = 7.12$, $p < .001$) age effect and non-significant effects for examiners, gender, and interactions.

Seventy-seven percent of the students indicated that they liked the electronic task best.

Thirty students received perfect search scores (no repeated or omitted combinations). Thirty-six students achieved a Piagetian battery level of IIIb. Six students received both perfect search scores and a Piagetian battery level of IIIb. The group with perfect search scores had a mean electronic task level of IIIa and a mean Piagetian battery level of Low IIIa. Analysis of search patterns indicated that students with perfect search scores tended to use search patterns which required low memory loads, whereas students who achieved a Piagetian battery level of IIIb tended to use search patterns which required moderately higher memory loads and made more errors (repeats + omissions). Students with an electronic task level below IIIa tended to use incomplete random, or complex search patterns.

The low correlation (.26) between search-for-combinations scores and isolation-of-switches scores suggested that the electronic task consisted of two different tasks.

Conclusions

The electronic task is free of gender bias, can produce consistent results across three examiners, encourages high student motivation, and can detect intellectual growth across a broad range of student ages and intellectual abilities.

Students with a Piagetian battery level of IIIb tend to differentiate and integrate as they progress through the electronic task, and although most of them do not achieve perfect search scores, they are successful in doing the task. Students with perfect search scores tend to differentiate first and integrate at the end of the task. This finding could hold important implications for science teaching.

The electronic task appears to consist of two different tasks: combinatorial reasoning and isolation of variables. The tasks may be used separately or combined, but in either case special consideration must be given to protocols and scoring techniques. This finding helps to explain why some researchers questioned the utility of the original chemical task.

CONCURRENT SESSION G

Session G-2 Paper Set: Cognitive Structure

Presiding:
Edward L. Smith
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Limitations of Ausubel's Theory of Learning With Regard to Meaning and Cognitive Processing

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Measuring Cognitive Structure

James H. Stewart
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Cognitive Functioning: A Model for Learning and Problem Solving

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LIMITATIONS OF AUSUBEL'S THEORY OF LEARNING WITH REGARD TO MEANING AND COGNITIVE PROCESSING

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Ithaca, New York

The intent of this paper is to provide a general introduction to the following two papers in this paper set. This will be done by providing a brief history of the research line that generated these papers; the research line being one based upon the learning theory of David Ausubel (1963, 1968).

Additionally, this paper will explore the concepts of meaning and cognitive structure, especially as they relate to Ausubel. In this respect an indepth look at the Ausubel view of meaning will be presented, especially from the standpoint of looking at perceived present weaknesses. Once these weaknesses are presented the paper will then attempt to remedy those weaknesses, thus adding to the epistemological validity of Ausubel's theory. In so doing, the paper will develop the position that propositional meaning is an important component of cognitive structure. This will serve as an introduction to the second paper: When measuring a subject's cognitive structure one must be able to measure the propositional or semantic nature of that cognitive structure. Also, as a means of introducing the third paper the topic of cognitive processing as a necessary companion to cognitive structure will be overviewed. Again the position taken will be one of extending what is felt by this author to be a weakness in Ausubel's writing—an inadequate treatment of cognitive processes.

Ausubel, D. P. The Psychology of Meaningful Verbal Learning: An Introduction to School Learning. New York: Grune and Stratton, 1963.

Ausubel, D. P. Educational Psychology: A Cognitive View. New York: Holt, Rinehart & Winston, Inc., 1968.

MEASURING COGNITIVE STRUCTURE

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Recent papers appearing in the Journal of Research in Science Teaching (Shavelson, 1974; Preece, 1976a, 1976b) and other educational journals have increasingly reflected a concern with the assessment and portrayal of cognitive structure (knowledge structure, long-term memory). This focus reflects the position that at least part of the purpose of teaching science (or any body of knowledge) is to cause a student's cognitive structure to resemble the content structure of a discipline. As a result, numerous cognitive structure assessment measures, as well as means of representing the data collected, have been developed.

This paper will have two related purposes:

A. To severely critique cognitive structure measures and representational devices which do not deal with the specific propositional nature of the relationships among concepts. In other words, the concept of meaning is felt to be a necessary attribute of the concept of cognitive structure. Therefore measurement and representation of cognitive structure must deal with meaning. Some measures which do not deal with meaning and thus will be criticized include:

   1. Word Association Tests
   2. Graph (Tree) Construction Tasks
   3. Concept Mapping Tasks

B. To provide descriptions of measures or devices that:

   1. Make an attempt to capture the propositional meaning component of cognitive structure. These will include:

      a. The use of clinical interviews
      b. Graph Construction and Concept Mapping Tasks with labeled relationship lines
      c. Concept Relations Task.

   2. Can be used to portray the meaning component of Cognitive Structure.

      a. A method of portraying cognitive structure (which may also be used in representing content structure), borrowed from information psychology, the semantic network, will be discussed.

Preece, P. F. W. "The Concepts of Electromagnetism: A Study of Internal Representation of External Structure." *Journal of Research in Science Teaching*, 1976a, *13*(6), 517-524.

Preece, P. F. W. "Mapping Cognitive Structure: A Comparison of Methods." *Journal of Educational Psychology*, 1976b, *68*(1), 1-8.

Shavelson, R. J. "Methods for Examining Representations of a Subject-Matter Structure in a Student's Memory." *Journal of Research in Science Teaching*, 1974, *11*(3), 231-249.

COGNITIVE FUNCTIONING: A MODEL FOR LEARNING AND PROBLEM SOLVING

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As an extension of the ideas of meaning and cognitive structure developed in the second paper of this set, this paper will outline a model of learning and problem solving based on ideas derived from information processing models of memory and Ausubel's theory of meaningful learning.

A key element of Ausubel's theory of meaningful learning is the effect of existing cognitive structure on new learning. Ausubel states that for new learning to occur new knowledge must be integrated with existing relevant background knowledge (subsumers). However, Ausubel fails to explicitly describe the *cognitive processes* whereby new knowledge becomes integrated with existing cognitive structure. This is seen as a weakness of Ausubel's theory.

By drawing on ideas from information processing models of memory and problem solving, a model of learning and problem solving will be developed that explicitly deals with the cognitive processes that are required for learning. The model defines the conditions necessary for learning as:

1. existence of relevant background knowledge in cognitive structure, and
2. the *capacity to integrate* new knowledge with existing relevant knowledge in cognitive structure.

The capacity to integrate new knowledge with existing relevant knowledge in cognitive structure will be discussed in terms of various cognitive processes identified both by models of human memory (Lindsay and Norman, 1977) and theories of human problem solving (Newell and Simson, 1972).

In support of the model, results of a research study designed to test the model will be presented.

Lindsay, P. H. and Norman, D. A. *Human Information Processing* (2nd ed.). New York: Academic Press, 1977.

Newell, A. and Simson, H. A. *Human Problem Solving*. New Jersey: Prentice Hall, 1972.

CONCURRENT SESSION G

Session G-3 General Research

Presiding: Victor L. Willson
University of South Dakota
Vermillion, SD 57069

The Effects of Locus of Control and Method of Presentation on Pre-Service Teachers' Achievement

Willis J. Horak
Kurt Slobodzian
University of Arizona
Tucson, AZ 85721

The Effects of Process Skill Analysis on the Teaching of Data Collecting, Processing, and Interpreting

Russell H. Yeany
James R. Okey
William R. Capie
University of Georgia
Athens, GA 30602

Contrasts of ISCS Achievement Groups--Levels I & II

Thomas E. McDuffie
Saint Joseph's College
Philadelphia, PA 19131

THE EFFECTS OF LOCUS OF CONTROL AND METHOD OF PRESENTATION ON PRE-SERVICE TEACHERS'S ACHIEVEMENT

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Designing curricula and devising teaching methods to meet individual differences has long been a topic of educational research. Many researchers have noted that no single instructional process is optimal for all students (Glaser, 1968; Cronbach & Snow, 1969). However, only recently have studies investigated the inter-individual differences of students when exposed to various instructional procedures. The matching of instructional methods to students is the general area of aptitude-treatment interaction research. This study used the statistical analysis common to ATI research to investigate one such hypothesized relationship.

The purpose of this study was to investigate the relationship between pre-service teachers' locus of control and an application measure of science education achievement under a high and a low structured instructional treatment. The evidence of locus of control differentially affecting achievement is mixed. Some researchers show that internals attain higher achievement test scores, while others find very little relationship between locus of control and achievement test scores (Lefcourt, 1976). These mixed findings point out the need for studies investigating possible interactions between educational treatment and the locus of control dimension of cognitive style.

Subjects for this study were 80 college students enrolled in an elementary science methods class. The students were randomly assigned to one of the two groups on the first day of class. At this time the students were administered aptitude tests which included a measure of locus of control. Two alternative instructional programs were developed. The subject matter of these program modules dealt with planning science field trip activities for elementary school children. Both treatments contained identical introductory material. After the introduction, one treatment was designed in a high structure format. The students were taught in the traditional instructor lecture mode. As a group, they participated in a field trip experience with the instructor identifying activities elementary school children could do relative to the science processes. Follow up discussions were large group. The other treatment was designed in a low structure mode. The class identified various field trip sites and then individual students chose a site to visit. They individually identified activities elementary school children could do relative to the science processes. Follow up discussions were small group with students who experienced similar field trips sharing and comparing ideas.

The locus of control instrument used in this study was the James Internal-External Locus of Control Scale (James, 1957). It has high reported reliability and validity, and was normed on undergraduate college students similar to those involved in this study. The criterion measure was specifically designed for this study. It was an application level examination on the concepts presented. Data was analyzed utilizing multiple linear regression analysis techniques to test for the existence of possible aptitude-treatment interactions between locus of control and instructional procedures. The data were checked for disordinal interactions which were then analyzed by the Johnson-Neyman technique to find the areas of significant differences.

The analysis of the data indicated that the instructional treatments were related to the locus of control measure. Students in the two treatment groups did respond differentially to the alternative treatments. These findings are useful to teacher educators planning instructional modules for pre-service teachers.

Cronbach, L. J. and Snow, R. E. "Individual Differences in Learning Ability as a Function of Instructional Variables." (Final Report, U.S.O.E., Contract No. OEC-4-5-061264). Stanford University, 1969, ERIC ED: 029001.

Glaser, R. "Ten Untenable Assumptions of College Instruction." Educational Researcher, 1968, 49, 154-159.

James, W. H. "Internal Versus External Control of Reinforcement as a Basic Variable in Learning Theory." Unpublished doctoral dissertation, Ohio State University, 1957.

Lefcourt, H. M. Locus of Control: Current Trends in Theory and Research. New York: John Wiley & Sons, 1976.

THE EFFECTS OF PROCESS SKILL ANALYSIS ON THE TEACHING OF DATA COLLECTING, PROCESSING AND INTERPRETING

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The processes of science are central to the domain of science and are one of the factors which distinguish it from other human endeavors. They should play the same central role in teaching science. The purpose of this study was to assess the effects of training in the systematic analysis of science processes on the use of strategies for teaching data collecting, processing and interpreting.

In order to measure the above effects, 20 pre-service secondary science teachers were randomly assigned to one of the following treatments:

Treatment I (Experimental)

All subjects in this group were trained to use an observation guide to determine the type and frequency of data operations occurring in a classroom (e.g., collecting, ordering, and communicating) and who performs each (i.e., student or teacher). After becoming familiar with the guide through discussions and applications to model teaching sequences, these subjects were assigned to design and peer-teach a video-taped lesson which involved data collection, manipulation, and interpretation. Each subject then used the observation guide to complete a systematic self-analysis of their teaching behavior during a private viewing of their tape. A second process skill lesson was taught and also video-taped.

Treatment II (Comparison)

The subjects in this group received no special instruction in the analysis of process skill teaching strategies. As in Treatment I, they were assigned to teach a lesson involving data collection, manipulation, and interpretation to their peers. After this, they scheduled a private unstructured viewing before teaching a second video-taped lesson involving the same skills.

Prior to treatment all subjects demonstrated proficiency in the process skills during self-paced instructional activities.

Data on the dependent variables were collected by trained observers who used the Data Processing Observation Guide (DPOG) to measure teacher/student behavior. The DPOG can be used to determine the frequency of ten different data processing operations (e.g., collecting, ordering, expanding, and displaying) and teacher-student interactions in a science classroom. Several indices of the relative occurrence of data processing operations involving both students and teachers can be generated with the instrument. Six of these indices were selected as the dependent variables of interest in this study. Analysis of variance procedures were used to identify significant differences in index means which could be attributed to treatment efforts.

The results of data analysis indicated that the process skill teaching behavior of the subjects was significantly influenced by the initial treatment involving training in the use of the structured analysis system on three of the six indices (p = .003, .03 and .005). On the first tape, the experimental subjects received higher values on all the indices which measured the level of student involvement in data operations. The second lesson continued to be significantly more student oriented when compared to the comparison group as indicated by significant differences on the same indices (p = .04, .005 and .001). A dependent sample analysis for changes in teaching behavior from the first lesson to the second indicated that there were no significant changes within either group which could be attributed to tape viewing procedures. The initial changes in teaching behavior due to training in strategy analysis were persistent but no further changes resulted from viewing the first tape.

The results indicate that teaching behavior can be influenced when subjects are provided with an observation system which allows them to examine the operations and interactions which constitute a lesson. After analysis, teaching is characterized by greater pupil involvement in the lesson. These changes are persistent to a second taped lesson. This persistence may be due to self analysis of the first tape or residual effect from initial training in the analysis system. Additional research is needed to establish the influence of initial training without self analysis.

CONTRASTS OF ISCS ACHIEVEMENT GROUPS - LEVELS I & II

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Factors associated with top and bottom achievement groups for students enrolled in the ISCS program were the principal interest of the present research. Differences in the characteristics associated with achievement level in and between Levels I and II were determined. Two specific questions were addressed.

1. Are there significant differences between achievement groups within Levels I and II?

2. Are there significant differences between the factors associated with the top or bottom achievement groups from Level I to Level II?

Two aspects of earlier work underlie the investigation. In the first, significant differences between achievement groups were found at Level I. An examination of Level II is a direct extension of this effort. Relatively inaccurate predictions of achievement at Level II is the second aspect. Differences on Level I were poor predictors at Level II. Changes in the distinguishing factors from one level to the next might explain the discrepancies. In general, differential treatment effects are being examined with regard to ISCS Levels I and II.

Methodology in Design

A quasi-research design was utilized to examine the achievement of a class, upon completion of both ISCS Levels I and II. Achievement level was a function of a student's results on a 40-item multiple choice examination, developed, refined and standardized for the appropriate ISCS level. Contrasts were made between the extreme groups on a series of ten factors through an analysis of variance. Comparisons between levels were the second stage. The variance found between top and bottom groups at the end of the first and second year was analyzed. Since the internal validity of such a longitudinal approach can be a source of difficulty, a second comparison group of ISCS students was also examined.

Instruments and Data

Data collection involved a class of students who were enrolled in a middle to upper middle class suburban school district. A district-wide commitment to ISCS had been made and the program implemented several years prior to the investigation. The sample included students of the class which entered the program in 1975 and for whom all data was available—Level I n = 362, Level II n = 306. The comparison group was enrolled in Level II during 1977 (n = 298).

Information was collected on a series of ten factors including aptitude, attitude, knowledge and skills. The quantification of the data involved a number of well known tests plus an achievement index developed and refined by the school district. The instruments include the SCAT and STEP tests, Moore's Scientific Attitude Inventory.

Results and Conclusion

Not surprisingly significant differences on SCAT quantitative and reading scores were found between the top and bottom groups on both levels. Less predictable was the importance of attitude toward science. The greatest differences in Level I were on emotional attitude toward science not on aptitude or skills. The role of these variables is reversed with grade eight. Here as the literature suggests reading and mathematical aptitude become most important.

While differences between levels were found on attitude and aptitude, the magnitude was considerably less than that detected within groups. By the same token, differences between levels were much greater than those between the two Level II groups.

Enthusiasm, as indicated by a positive attitude, should be an explicit goal of teachers in ISCS Level I. During the first year, high achievement all but depends upon attitude. The conceptual demands of the material included in Level II downgrade the role of attitude in favor of reading and mathematical ability, but attitude remains a prime concern.

Changes in the factors associated with achievement from one level to the next are greater than from one group to the next. Hence, attempt to use differential treatment effects for predictors necessitate development of specific relationships for each level.

CONCURRENT SESSION H

Session H-1 Critique: Teacher Behavior

Presiding: R. G. Mitias
Ohio University
Athens, OH 45701

The Effects of Alternative Practice Methods on Science Teacher Explaining Behavior and Student Outcomes

William R. Capie
James R. Okey
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The Relative Effects of Modeling on the Acquisition of Wait-Time by Preservice Teachers and Concommitant Changes in Dialogue Patterns and Pupil Performance

Linda R. DeTure
Alachua County Schools
Gainesville, FL 32601

Discussant: John T. Wilson
University of Iowa
Iowa City, IA 52242

THE EFFECTS OF ALTERNATIVE PRACTICE METHODS ON SCIENCE TEACHER EXPLAINING BEHAVIOR AND STUDENT OUTCOMES

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Rationale

This experimental study was designed to determine the treatment effects of systematic analysis and self-practice, peer practice and student practice in explaining on subsequent science teaching behavior and on student outcomes in science.

The process of explaining is central to effective teaching. Even the casual classroom observer can attest to the importance of this skill. The early work of Rosenshine and Furst (1973) describing clarity and Johnson's competency verification study (1977) further support the essential role of explaining. Two viable research areas are determining valid acquisition strategies and identifying specific explaining skills which affect learning.

Miltz (1971) defined a set of explaining behaviors in a training program evaluation where judges rated post-training explanations superior to initial attempts. Pool (1976) used a modified training study where both treatment and control group teachers taught a standard lesson to pupils. Pupils of trained teachers scored higher on a standard concept test.

The present study differs in that both teaching behavior acquisition and pupil outcomes are assessed. In addition, natural teaching activities were used.

Methodology

Twenty-three students in a secondary science teaching methods course were randomly assigned to three treatment levels. All subjects completed a four-hour program dealing with various dimensions of explaining science concepts. Principles included sequencing generalizations and examples using precise language, focusing, etc. Two hours of practice with systematic analysis followed in three different contexts. Group I students recorded brief explanations and analyzed their own topics. Group II students recorded brief explanations made to a peer who assisted in analysis. Group III students were assigned to public schools where they recorded and analyzed explanations made to students in science classes. A test of explaining knowledge was administered after the practice sessions.

Prior to instruction all students recorded a brief explanation made to a group of peers. Subsequent to instruction all students taught and recorded two lessons with public school pupils. The first was a short single lesson on a specified science topic. The second was a brief lesson sequence where students had pupils respond to pre- and post-tests. Both of these lessons were recorded.

Scores reflecting explaining knowledge, pupil learning, pupil attitudes and skill acquisition for students in the three treatment groups were analyzed using analysis of variance procedures.

Data Sources

Data were generated by teacher education students and by pupils they taught. The teacher's knowledge of explaining was assessed with a paper and pencil instrument which required knowledge and application of the explaining principles. Pupil learning in science was assessed with a teacher constructed test keyed to instructional objectives of the lesson sequence. Standardized gain scores were used for analysis. Pupil attitudes regarding instruction were assessed by a questionnaire constructed by the investigators.

The teachers' explaining behavior was assessed by two judges who monitored the tape of the single lesson with pupils. Observations were made of the number of generalizations and examples used and their sequence in instruction. Sixteen measures of frequency were gleaned from explaining observation systems. In addition, the number of verbal focusing behaviors was noted. Quality judgments were made as well. Each time a rule or generalization was used, judges rated its quality on seven dimensions such as clarity, simplicity, relevance, etc. These observations were made on a Likert-type scale with the end-points defined. A mean quality rating was computed for each dimension and the sum was totaled reflecting an overall quality index.

Results/Conclusions

Each of the quality dimensions favored the self-practice group as did all eight computed quality indices. The probability associated with these 22 F-ratios ranged from .13 to .40, the mean being .23. A Cochrans test for homogenity of variance revealed that the peer group was also much more homogenous than either of the others. There were no differences in the scores of explaining knowledge, the pupil gain scores, or pupil attitudes.

The consistent pattern of near significant differences on 22 variables suggests that self-study is most effective in improving explanation quality. Such findings have potentially broad implications to those planning science teacher training programs for both field experience and peer practice activities which are costly in terms of student or class time.

Johnson, C. E. and others. A Summary of the Competency Verification Survey Study with Selected Findings. Athens, Georgia: Georgia Department of Education Beginning Teacher Evaluation Project, University of Georgia, 1977.

Miltz, R. J. "Development and Evaluation of a Manual for Improving Teachers' Explanations." Unpublished doctoral dissertation, Stanford University, 1971.

Pool, K. W. "Preservice Teacher Education in Explaining and Its Effect Upon Elementary Pupils' Learning of A Concept." Unpublished doctoral dissertation, University of Georgia, 1976.

Rosenshine, B. and Furst, N. "The Use of Direct Observation to Study Teaching," in R. M. Travers, ed. Second Handbook of Research in Teaching. Chicago: Rand McNally College Publishing Company, 1973.

THE RELATIVE EFFECTS OF MODELING ON THE ACQUISITION OF WAIT-TIME BY PRESERVICE ELEMENTARY TEACHERS AND CONCOMMITANT CHANGES IN DIALOGUE PATTERNS AND PUPIL PERFORMANCE

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The purpose of this study was to devise an effective method for training teachers to extend wait-time, defined as the time a teacher pauses after asking a question, wait-time I (WTI), and after a student response, wait-time II (WTII). The two treatments, a video and an audio model, were tested with and without a feedback component. The outcome variables measured were mean length of teacher talk (MLTT), mean length of student talk (MLST), a proportion of teacher talk (PTT) and a student performance measured by process skills test.

Fifty-two preservice elementary teachers were randomly assigned to four groups: audio no feedback; audio feedback; video no feedback; and video feedback. The subjects taught a series of three science inquiry lessons to four fourth or fifth graders in a microteaching setting. Each teaching session was audio recorded and entry level wait-times were calculated. Before Session 2 teachers observed either a video or audio model depicting the desired criterion wait-time of three seconds. Subjects taught Session 2 using extended wait-time. Before Session 3 teachers in the feedback group listened to and rated their tape from Session 2 to determine frequency of criterion wait-time. The no feedback group read an inquiry related article. Both groups were instructed to use extended wait-time for Session 3. The 208 children were administered the process test at the end of each session.

Mean lengths of wait-time I and II and the dialogue variables were calculated from the audio tapes with a servo-chart recorder. Treatment effects were analyzed with a split plot factorial ANOVA design. Multiple regression analysis was performed for each teaching session with wait-time II as the dependent variable.

The results revealed that the video group achieved significantly longer wait-time II than the audio group with both groups improving significantly from entry level. The effect of feedback resulted in an increase in wait-time significant at the 0.076 level of probability. Feedback was sufficient to bring the video group to a mean wait-time of 3.6 seconds. Wait-time I increased significantly from Session 1 to Session 3 but the increase did not reach the desired criterion for any session.

Of the outcome variables both mean length of student talk and the proportion of teacher talk were highly correlated with wait-time for all three teaching sessions. As the length of WTII increased MLST increased and PTT decreased. The mean length of teacher talk was found to correlate with WTII significantly only for Session 2 during which MLTT decreased and WTII increased. It was suspected that teachers initially attempted to increase wait-time by controlling their length of utterance. MLTT increased to entry level for Session 3 and did not correlate significantly with wait-time. Test scores did not correlate significantly with wait-time for any teaching session possibly because of the wide fluctuation of the wait-time variable between the teaching sessions.

This study suggests that a video model with feedback would be an effective training method for increasing teacher's wait-time. The audio feedback model with slight modifications might prove to be an effective alternative if expense requirements prohibit the production and use of the video model.

Campbell, J. and Rose, R. In Rowe, M. B.,"Reflections of Wait-Time: Some Methodological Questions." *Journal of Research in Sciences Teaching*, *11*(4), 263-279.

Chalker, J. W. "A Study Using Interaction Analysis of the Relationships Between Teacher Dogmatism and the Reflective Method of Teaching Social Studies." Ed.D. dissertation, University of Pennsylvania, 1972.

Garigliano, L. T. "The Relation of Wait-Time to Student Behaviors in Science Curriculum Improvement Studies." Ed.D. dissertation, Columbia University, 1972.

DeTure, Linda R. "The Relative Effects of Modeling on the Acquisition of Wait-Time by Preservice Elementary Teachers and Concommitant in Dialogue Patterns and Pupil Performance." Ph.D. dissertation, University of Florida, 1976.

Lake, J. "The Influence of Wait-Time on the Verbal Dimension of Student Inquiry Behavior." Ed.D. dissertation, Rutgers University, 1973.

Lawlor, F. X. "The Effects of Verbal Regard on the Behavior of Children in the Primary Grades at a Cognitive Task Typical of the New Elementary Science Curricula." *Journal of Research in Science Teaching*, 1970, *7*(4), 327-340.

Moriber, G. "Wait-Time in College Science Classrooms." *Science Education*, 1971, *55*, 321-328.

Rowe, M. B. *Teaching Science as Continuous Inquiry*. New York: McGraw-Hill Book Co., 1973.

____________. "Pausing Phenomena: Influence on the Quality of Instruction." *Journal of Psycholinguistic Research*, 1974a, *3*(3), 203-223.

Rowe, M. B. "Reflections on Wait-Time: Some Methodological Questions." *Journal of Research in Science Teaching*, 1974b, *11*(3), 263-279.

____________. "Relation of Wait-Time and Rewards to the Development of Language, Logic and Fate Control: Part II-Rewards." *Journal of Research in Science Teaching*, 1974c, *11*(4), 291-308.

CONCURRENT SESSION H

Session H-2 Instruction

Presiding:
Burton Voss
University of Michigan
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Development and Validation of a Televised Test of Science Processes

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Bethlehem, PA 18018
and
Michael Szabo
Paul W. Welliver
Dennis M. Roberts
Pennsylvania State University
University Park, PA 16802

Changing Attitudes and Checking Achievement... Measuring the Effectiveness of an Interdisciplinary Approach to Science

Lorraine A. Popowicz
Anna Marie College
Paxton, MA 01612

Effects of Using Photomicrographs on Achievement and Attitude in High School Biology

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University of Georgia
Athens, GA 30602

DEVELOPMENT AND VALIDATION OF A TELEVISED TEST OF SCIENCE PROCESSES

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Moravian College
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and

Michael Szabo
Paul W. Welliver
Dennis M. Roberts
The Pennsylvania State University

Objectives

This project describes the development of a resource for the identification of science process skills in young (grades 4-7) children. An existing test was modified for presentation in a broadcast instructional television (ITV) format. Field-based normative and validation data were collected and analyzed using established procedures.

Theoretical Rationale

National curriculum projects and some research undergird the perceived value of teaching science processes. Numerous projects to define or assess process competencies have been reported in the literature. The similarities and differences of these project findings will be summarized as a basis for the present project.

Some research and development with televised testing has been conducted in the areas of visual literacy, reading skills, and science knowledge; no evidence was found that science process skills have been measured through broadcast ITV.

Methodology

Tannenbaum's Test of Science Processes was selected for its: 1) comprehensiveness relative to theoretical science processes and 2) dependence upon the presence of pictorial stimuli to elicit science processes. The TOSP was modified by reducing the number of items using judges' opinions and item analysis data, and reducing the reading level of test questions. Combined with revision of all visual stimuli and conversion to a televised format, the modified test was deemed appropriate for grades 4-7.

Data Sources

The first pilot study served to determine the amount of response time allocated per item. Further data suggested editing changes. A subsequent pilot study collected data for statistical standardization (e.g., item analysis, preliminary norms, and reliability). A substantial validity study was conducted using correlational analysis between scores on the Televised Test of Science Processes, selected process tests, and general ability scores available from participating school districts.

Findings

Science educator judges rated 68 of the 96 items acceptable for the intended audience. Readability modifications reduced the reading level of the materials approximately three grade levels. Average item response time was established at 30 seconds. Item analysis criteria eliminated 28 items, leaving 40. The test is administered in two one-half hour time segments.

A reliability estimate based upon a sample of 802 fifth graders was .82 and rose to .91 when adjusted for test length (to 96 items). The validity coefficient with The Science Process Test was .66. Correlation with an intelligence test was modest (.53) but significant. Sub-analyses for specific processes was not incorporated into this phase of the project.

Educational Significance

This project has produced a useful and adjunct resource to the expanding thrust to increase inquiry oriented behaviors of elementary teachers in the State of Pennsylvania through Science for the Seventies. In addition, it provides a vehicle for assessing science competencies in young children. The data generated can be used for research, science process curriculum evaluation, instructional improvement, and building awareness of science processes on the part of practicing school personnel.

CHANGING ATTITUDES AND CHECKING ACHIEVEMENT...MEASURING THE EFFECTIVENESS OF AN INTER-DISCIPLINARY APPROACH TO SCIENCE

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The purpose of this study was to determine whether an interdisciplinary approach to teaching high school biology had a positive effect on students' attitudes toward science. . .but not at the expense of cognitive achievement in science.

Positive attitudes toward science are not a spontaneous happening of our age—an age in which society is enjoying the fruits of science in the form of the highest standards of living in history. Appreciation is not the same as understanding. Withey (1959) in a public opinion survey study noted that although the general public was found to be quite appreciative of science, it also questions science, watches it alertly, and to some extent mistrusts it. The development of healthy, positive attitudes regarding the scientific enterprise and its practitioners is one of the major responsibilities of science educators at all levels.

Integration of science with other disciplines (cross-disciplinary approach) is one answer to the question of how to bring about positive attitudes toward science (Kahn, 1962; Cossman, 1967). Interdisciplinary approach in this investigation referred to the combining of the traditional elements of the Modern Biology program by James Otto and Albert Towle (1969) along with an art element; i.e., the applied work of representation; decoration on surfaces together with the techniques and crafts associated with them.

Art may be basic to important vocational fields in at least two evident ways (Schwartz, 1970). One way could be defined as the contribution that creativity makes to the totally functioning individual. The other takes on a more impersonal relationship that may exist among learning disciplines. If, as contended by art specialists (Conant, 1964; Tolces, 1956) art activity induces creativity, we may assume that positive attitudes are transferrable to other fields. This is an assumption rather than an established hypothesis. Nevertheless, possibilities for such relationships have not been tested. Creative education has not yet become the significant force in the schools today. With this study, speculation may be in order to see just how art creativity would and could contribute to positive attitudes toward science.

* * * * *

Two school settings were involved in the study: School A (N = 235) was the experimental school in which a treatment (Biology with Art) and a control (Biology) group design was used, and School B (N = 120) was used exclusively as a control school in order to test for a possible "spillover" effect. In School A, the study involved two teachers and eight "college bound" tenth grade biology classes. Each teacher taught two treatment and two control groups. In School B, four classes were randomly selected as the control group from a total of twelve "college bound" tenth grade biology classes. The generalizability of any findings of this study would be restricted to tenth grade "college bound" classes using the *Modern Biology* program which are conducted in school settings similar to School A. School A was a Catholic high school located in a Massachusetts suburb, with predominantly white and middle class background students.

Although the specific question the study answered: Is there a significant difference in attitude toward science between the treatment and the control groups?, what the study also wished to test was that the increase in achievement in the treatment group was not significantly less than the increase in the control group over the period of the treatment. Thus, two dependent variables were investigated: attitude toward science and cognitive achievement in science. The instruments used to operationalize these variables by pre-test and post-test measures were the *Scientific Attitude Inventory* (Moore and Sutman, 1970) and the *Cooperative Science Test in Biology* (ETS, 1965). In addition to the treatment variable, three other independent variables which could possibly have had a "systematic" effect on performance on the dependent variables were included in the design of the study: intelligence, teacher and sex.

The principal statistical evaluation included an analysis of covariance. A fixed model using a replication of treatment x levels design (AxLxR) was used (Lindquist, 1953). The main factor (A) was the treatment factor with two levels (treatment, control). The levels factor (L) was IQ with three levels (average, above average, superior). The replication factor (R) was a teacher blocking factor (R) with two blocks (teacher #1 and teacher #2). The design is outlined below (Note: there are 12 cells).

	TREATMENT			CONTROL		
	Average IQ	Above Average IQ	Superior	Average IQ	Above Average IQ	Superior
Teacher #1						
Teacher #2						

The results revealed that boys who were involved in art activities along with their usual coursework in biology, consistently developed significantly more positive attitudes toward science than boys and girls studying the same biology course without the integrated art element. This finding for boys was found to be generalizable to both teachers and across all IQ levels. For girls however, the treatment effect on attitude interacted significantly with teacher. A more positive change in attitude toward science was found for the girls in the treatment classes for only one teacher.

Pertinent to the intent of this study for considering achievement, it was concluded that the interdisciplinary approach to teaching biology integrated with art did not have a negative effect on achievement.

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EFFECTS OF USING PHOTOMICROGRAPHS ON ACHIEVEMENT AND ATTITUDE IN HIGH SCHOOL BIOLOGY

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and

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Objectives and Rationale

Effective use of the microscope and subsequent success in a biology course are often related to a student's ability to identify a variety of plant and animal tissues from descriptions in a laboratory manual or from a verbal description supplied by the instructor. Students' difficulties with scientific terminologies are compounded when it is necessary to relate the term to actual structures viewed under the microscope. The purpose of this study was to evaluate the use of photomicrographs as a means of improving a student's ability in associating the meaning of scientific terms that describe anatomical structures of plants with the actual structures.

Methodology and Design

A Campbell and Stanley Posttest-Only Control Group Design was used to compare student achievement in recognizing and properly identifying plant anatomical features using two methods of instruction. A control group was instructed by conventional methods and an experimental group was instructed by the same conventional methods but supplemented with photomicrographs of the anatomical features. The study included analysis of male and female performance as well as difference between ability levels of students. Four hundred twenty-one students and five teachers in high school biology at a New York State high school participated in the study.

Instruments and Data

The posttest was a laboratory practical examination which required students to move to 33 prescribed stations. Each station consisted of a tissue to be viewed under a microscope and a 3 x 5 card that contained one question. Each test item had four choices as possible answers with one indisputable correct response to the question posed.

The data from the achievement test instrument were analyzed by a multifactor analysis of variance employing the Statistical Package for the Social Sciences (SPSS) for unequal N's. Multifactor analysis of variance was used to compare the two treatment groups on the main effects of: (a) treatment, (b) gender, (c) ability level, and (4) instructor. Analysis of variance was used to test for interaction effects between: (a) instructor and treatment, (b) instructor and gender, (c) instructor and ability level, (d) gender and treatment, (e) gender and ability level, and (f) treatment and ability level. A post-hoc analysis using the Newman-Keuls multiple comparison test was used to determine which of the four ability level means were significantly different from each other.

To evaluate the attitudes and opinions of the students participating in the study, a student assessment questionnaire was distributed to each student. Data collected from the student assessment forms were analyzed on the basis of mean response and standard deviation. Five t-tests were made to compare the attitude of the treatment groups on questions that were common to both questionnaires.

Results and Conclusions

This experiment in the use of photomicrographs in the teaching of plant anatomy in high school biology indicated that students in the experimental classes achieved at a significantly ($p < 0.001$) higher level than students in the control classes. There was a significant main effect for gender differences with boys scoring significantly ($p < 0.05$) higher than girls. All four experimental ability levels achieved significantly ($p < 0.001$) higher than the control ability levels. The post-hoc analysis revealed the high ability level achieved significantly ($p < 0.05$) above the other three ability levels. Interaction for two unique combinations of variables under investigation were found: teacher x treatment and teacher x ability level.

Data from the student assessment analysis revealed that students expressed favorable reactions to the slides and indicated a preference for them over conventional instruction alone.

The results of this study provide evidence that the use of photomicrographs in high school biology significantly and positively influenced cognitive achievement.

CONCURRENT SESSION H

Session H-3 Paper Set: Instruction

Presiding:
Neil B. Sendelbach
Michigan State University
East Lansing, MI 48824

A Comparative Laboratory Study of the Effects of Two Teaching Strategies on Students' Achievement Motivation, Problem Solving Ability, and Selected Classroom Behaviors

Charles C. Matthews
Florida State University
Tallahassee, FL 32306

A Comparative Laboratory Study of Problem-Solving Ability and Confidence for Sixth Grade Science Students Exposed to Two Contrasting Teaching Strategies

David J. McKee
City of Tallahassee
Tallahassee, FL 32303

A Comparative Study of the Relationships Between Classroom Behavior and Cognitive Characteristics of Students Exposed to Two Science Teaching Strategies

Dorothy Schlitt
Florida State University
Tallahassee, FL 32306

A Comparative Study of the Effects of Two Teaching Strategies in Science on Students' Need-Affiliation and Teacher Dependency Behaviors

Jose L. Vinelli
Florida Department of Education
Tallahassee, FL 32301

A Comparative Laboratory Study of the Effects of Two Teaching Strategies on Students' Attitudes and Self-Concepts in Science

Sudhir B. Abhyankar
Florida State University
Tallahassee, FL 32306

A COMPARATIVE LABORATORY STUDY OF THE EFFECTS OF TWO TEACHING STRATEGIES ON STUDENTS' ACHIEVEMENT MOTIVATION, PROBLEM SOLVING ABILITY, AND SELECTED CLASSROOM BEHAVIORS

Charles C. Matthews
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Rationale

This paper is a part of the most recent research conducted by Project LEO, a research cooperative studying learning environments and outcomes. A number of researchers in recent years have found relationships between specific teaching strategies and factors which may be considered to be indicators of learning. During recent years, investigators in Project LEO have studied the learning of elementary school children and high school students as this learning relates to two specific, quantitatively defined instructional strategies—called "Student-Structured Learning in Science" (SSLS) and "Teacher-Structured Learning in Science" (TSLS). This study is an extension of this previous research into the middle school range.

Summary of Methods

This study investigated the effects of two contrasting teaching strategies on the achievement, problem solving ability, and selected classroom behaviors of students in middle school science. Treatment was controlled by teacher training and daily observation utilizing teacher behavior categories from the Science Curriculum Assessment System. Pre- and post-tests were administered prior to and following a six-week treatment period. Student behaviors were also coded daily using the SCAS classroom interaction categories. Appropriate hypotheses were stated and tested utilizing pre- and post-test scores on a one-to-one problem solving interview, and an interaction index computed from classroom behavioral data on individual students. Ninety sixth, seventh and eighth grade students were taught by the SSLS strategy; and an equal number of sixth, seventh and eighth graders were taught by the TSLS strategy. Treatment groups were assigned by random selection of subjects from grade-level populations and classroom behavioral data were sampled randomly. Observer agreement was established weekly by a standard reliability coefficient.

Results

The paper includes a detailed description of data analysis leading to the following findings:

1. No significant difference in achievement motivation between SSLS and TSLS was observed.

2. SSLS students scored significantly higher on problem solving tasks than did TSLS students.

3. SSLS students interacted more with each other on lesson-related matters than did TSLS students.

4. Sex was not a significant variable in determining achievement motivation, problem solving ability or student-student interaction in the classroom.

Implications

This study suggests that learning (as defined by the variables considered) is significantly higher under SSLS instructional strategies than under TSLS instructional strategies with no loss in motivation. Lesson-related discussions among students are significantly higher in SSLS than in TSLS. This suggests that middle school science teachers who intend to teach problem solving and who find student-student interaction to be tolerable should choose the SSLS strategy rather than the TSLS strategy.

A COMPARATIVE LABORATORY STUDY OF PROBLEM-SOLVING ABILITY AND CONFIDENCE FOR SIXTH GRADE SCIENCE STUDENTS EXPOSED TO TWO CONTRASTING TEACHING STRATEGIES

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Rationale

This is part of the cooperative research effort collectively known as Project LEO (Learning Environments and Outcomes). The study investigated effects of two contrasting teacher behavioral patterns—Student-Structured Learning in Science (SSLS) and Teacher-Structured Learning in Science (TSLS)—upon the problem-solving ability and confidence levels of sixth grade students. This extends a previous six-week pilot project to a fifteen-week treatment period.

Summary of Methods

The two contrasting teacher behavioral patterns were maintained through teacher training and daily use of the Science Curriculum Assessment System. Students under both strategies were exposed to identical materials, room, and teachers. One hundred students in four classes were given a fifteen-week treatment period, at the end of which each student was individually given a problem-solving and confidence interview. Student sex, ethnicity, and available IQ data were compiled.

Results

Data were analyzed using the Statistical Package for Social Sciences (SPSS). Results of analysis of covariance and Pearson correlation coefficients were as follows:

1. SSLS students performed significantly better on problem-solving tasks.

2. SSLS students had significantly higher confidence levels.

3. A significant two-way interaction between the ethnicity and strategy variables indicated that black students in SSLS classes performed better on problem-solving tasks than did blacks in TSLS classes.

4. A significant three-way interaction between sex, ethnicity, and strategy variables indicated that black male students in SSLS classes performed better on problem-solving tasks than other groups while black male students in TSLS classes showed the lowest performance. Also, black females in SSLS classes performed better than black females in TSLS classes.

5. Significant Pearson correlation coefficients were found for problem-solving ability and confidence level, for problem-solving ability and IQ, and for confidence level and IQ.

Implications

Conclusions to be noted in this study are the differential strategy effects upon problem-solving ability and confidence level. For teachers interested in promoting a student's ability to solve problems while improving self-confidence, the SSLS strategy is the obvious choice. Since SSLS classes function better to improve problem-solving skills of black students, while working just as well for white students, educators should become aware of the potentially prejudicial effects of the more traditional TSLS classes.

A COMPARATIVE STUDY OF THE RELATIONSHIPS BETWEEN CLASSROOM BEHAVIORS AND COGNITIVE CHARACTERISTICS OF STUDENTS EXPOSED TO TWO SCIENCE TEACHING STRATEGIES

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Rationale

This paper is part of a study which describes the most recent extension of the research being conducted by Project LEO (Learning Environments and Outcomes) investigators. Previously reported research dealt with the effects of two quantitatively defined teaching strategies, Student Structured Learning in Science (SSLS) and Teacher Structured Learning in Science (TSLS), on the characteristics and learning outcomes of elementary school and secondary school students.

Summary of Methods

This study investigated whether student behaviors exhibited in SSLS and TSLS classroom environments were related to the cognitive development indicators of conservation on four Piaget-type interview tasks (number, area, weight, volume). The tasks were administered by trained undergraduate and graduate students in Science Education and administered on an individual basis both pre- and post-treatment. Two groups of sixth, seventh and eighth grade students were randomly selected and assigned to either a TSLS or SSLS classroom. Classroom behavioral data were sampled randomly over a six-week period by trained observers; agreement was established weekly by means of a standard reliability coefficient. The recording of student behavior was defined by means of the SCAS (Science Curriculum Assessment System) categories.

Results

Data analyses in this study, which are described in the paper, suggest:

1. Conservers in TSLS classrooms exhibit more non-lesson related behaviors than conservers in SSLS classrooms.
2. In TSLS classrooms, conservers exhibit more L2 behavior (following directions) than non-conservers.
3. In SSLS classrooms, conservers exhibit more L3 behavior (making up own activities) than non-conservers.
4. Differences exist in student-student interaction categories L7 (receiving ideas) and L9 (giving ideas) as a function of cognitive characteristics, strategy and grade level.

Implications

This study suggests that some cognitive characteristics of students may be related to specific student behaviors as a function of classroom strategy. It is suggested that since more "cognitively advanced" students spend more time doing lesson-related activities of their own choice and engage in less non-lesson related behavior in SSLS classrooms, a TSLS environment may be less productive for such students. While student-student interaction is more likely to be encouraged in an SSLS environment, the level of such interaction may be a function of the age (grade level) of the student as well as the cognitive characteristics of the student.

A COMPARATIVE STUDY OF THE EFFECTS OF TWO TEACHING STRATEGIES IN SCIENCE ON STUDENTS' NEED-AFFILIATION AND TEACHER DEPENDENCY BEHAVIORS

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This study, which is part of a research conducted under Project LEO (Learning Environments and Outcomes) dealt with the effects of two teaching strategies (Student Structured Learning in Science versus Teacher Structured Learning in Science) on middle school science students' need-affiliation and teacher dependency behaviors.

Under both treatments students worked with the same kind of materials. SSLS students were free to design their own activities, received no directions as to what to do, and were neither praised nor evaluated for their performance. TSLS students received directions to be followed step by step while working with the materials, received positive and negative verbal reinforcements from the part of the teacher, and were required to finish each activity before proceeding with the next assignment.

Pretests were administered to the students during the first week of April, and posttests during the last week of May 1975. Teachers and students behaviors were coded daily using the SCAS Classroom Interaction Categories by faculty members and trained graduate students. Reliability between coders was checked twice a week against a standard coder by means of the Scott's Reliability Coefficient π, and maintained throughout the study at a level of 0.75 and above.

The findings of this study seem to confirm that the need for affiliation, in general, is a more salient feature among girls than among boys at the sixth grade level.

Among seventh and eighth graders a significant interaction of method by sex was found. Within the TSLS strategy girls exhibited higher n-Affiliation than boys, as it was the case among sixth graders. This pattern reversed itself within the SSLS strategy where girls showed lower n-Affiliation than boys. Anxiety reduction among female students within the SSLS setting is offered as a possible explanation to this fact, and a need for affiliation of the type that Festinger, Pepitone and Newcomb call "individuation" is suggested as the possible cause of the higher n-Affiliation exhibited by boys.

With respect to the students' dependency upon the teacher, as measured by the Teacher Dependency Index, the general pattern is simpler: TSLS students exhibit higher teacher dependency than SSLS students.

If the science teacher is concerned with promoting students' independence in the manipulation of materials and influencing their affiliative tendencies, according to this study, SSLS strategy seems to be a better approach than TSLS strategy among seventh and eighth graders.

A COMPARATIVE LABORATORY STUDY OF THE EFFECTS OF TWO TEACHING STRATEGIES ON STUDENTS' ATTITUDES AND SELF-CONCEPTS IN SCIENCE

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Rationale

This paper is a part of the most recent research conducted by Project LEO, a research cooperative studying learning environments and outcomes. A number of researchers in recent years have found relationships between specific teaching strategies and factors which may be considered to be indicators of learning. During recent years, investigators in Project LEO have studied the learning of elementary school children and high school students as this learning relates to two specific, quantitatively defined instructional strategies called "Student Structured Learning in Science" (SSLS) and "Teacher-Structured Learning in Science (TSLS). This study is an extension of this previous research into middle school range.

Summary of Methods

This study investigated the effects of two contrasting teaching strategies on students' attitudes and self-concepts in science. Treatment was controlled by teacher training and daily observation utilizing teacher behavior categories from Science Curriculum Assessment System. Pre- and post-tests were administered prior to and following a 15-week treatment period. Appropriate hypotheses were stated and tested utilizing pre- and post-test scores on attitudes towards science and self-concepts in science. Forty-six sixth grade students were taught by the SSLS strategy and 42 were taught by the TSLS strategy. Treatment groups were assigned by random selection of subjects from sixth grade population and classroom behavioral data were sampled randomly.

Results

The paper includes a detailed description of data analysis leading to the following findings:

1. No significant difference in students' attitudes toward science between SSLS and TSLS was observed.

2. Male sixth grade students had scored significantly higher on the attitude toward science than their female counterparts.

3. Male students in the SSLS classroom scored significantly higher on the attitude test than the male students in the TSLS classroom but the female students in the TSLS classroom scored significantly higher than the female students in the SSLS classroom.

4. No significant difference in students' self-concepts in science between SSLS and TSLS was observed.

5. Male sixth grade students scored significantly higher on the self-concept test in science than their female counterparts.

6. A significant positive correlation between students' attitudes towards science and their self-concepts in science was observed.

Implications

The findings of this study suggest that students who have better attitudes towards science also have higher self-concepts in science and that middle school science teachers who are concerned about students' attitudes and self-concepts in science can adapt to a single teaching strategy that would facilitate both the students' attitudes and self-concepts in science.

CONCURRENT SESSION H

Session H-4 **Paper Set: Cognitive Development**

Presiding:

Larry D. Yore
University of Victoria
Victoria, British Columbia, Canada
(on leave 1977-78 at the University of Iowa)

Effects of Taking Science on Formal Logical Reasoning Abilities

Richard J. Bady
Rutgers University
New Brunswick, NJ 08904

Cognitive Level and its Relationship to Aptitude, Achievement, and Training

George J. Pallrand
Rutgers University
New Brunswick, NJ 08904

Cognitive Development in Science Oriented Students

Robert N. Braun
Rutgers University
New Brunswick, NJ 08904

EFFECT OF TAKING SCIENCE ON FORMAL LOGICAL REASONING ABILITIES

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New Brunswick, New Jersey 08904

The recent interest in the tasks and theory of Jean Piaget is evidence of the relevance of the logical abilities he discusses for science education. These logical abilities are required for understanding many scientific principles and for conducting and interpreting research "scientifically." It seems reasonable that the achievement of these insights should be a goal of science curricula.

Previous research has indicated that science students tend to perform on Piagetian tasks better than non-science majors, on the average. Three possible explanations for this are: (1) The tasks are biased towards science students, (2) Taking science increases the likelihood that a student will develop the abilities being tapped, or (3) That students who have achieved these abilities or are likely to achieve them for other reasons, are just those students who are likely to take science. A corollary of this third explanation is that students who lack these abilities are likely to find science difficult and drop out into other fields.

To attempt to chose between these three explanations, several tasks ranging in difficulty were adapted from Wollman (1977), Wason and Johnson-Laird (1972) and Kuhn (1977). The tasks were given to seniors at a small private school which offered a wide range of humanities courses, thus avoiding the possible confounding between ability and science courses taken. PSAT math and verbal scores (taken in the ninth grade to avoid any possible effect of science courses on the scores) and number of science courses taken were used as independent variables in regression analyses to predict score on the tasks.

Results indicate that the three variables account for only about 25 percent of the variance in task scores. Almost all of this is shared equally between PSAT math and science courses taken. Thus (at least for this school) taking science contributes a significant but small amount towards the development of logical thought.

This model of analysis has great potential as a tool in curriculum evaluation. Since adequate control groups are not typically available against which to evaluate a curruculum-treated sample, it is useful to be able to measure the effect of the treatment variable both absolutely and with respect to background variables.

Kuhn, D. and Brannock, J. "Development of the Isolation of Variables Scheme in Experimental and 'Natural Experiment' Context." *Developmental Psychology*, 1977, *13*, 9-14.

Wason, P. C. and Johnson-Laird, P. N. *Psychology of Reasoning*. Cambridge, Massachusetts: Harvard University Press, 1972.

Wollman, W. "Controlling Variables: Assessing Levels of Understanding." *Science Education*, 1977, *61*, 371-383.

COGNITIVE LEVEL AND ITS RELATIONSHIP TO APTITUDE, ACHIEVEMENT, AND TRAINING

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The conceptual framework of Jean Piaget has markedly influenced those studying the cognitive development of adolescents. Although the system is comprehensive in describing development from infancy through adulthood, most research has concentrated on the evolvement of thought in small children. It has only been recently that the higher cognitive levels, particularly the formal operational level, have received considerable and deserved attention. Several researchers in science education have recently presented data which indicate that less than half of those taking college level science courses were not operating at the fully formal level. The influence of a number of variables including intelligence upon cognitive level have produced uncertain results. The question of influence of high school experiences upon cognitive level remains.

The study examined the relationship between aptitude and achievement (defined by SAT scores, class rank and credits earned, and I.Q.), and extent of high school exposure to subject matter disciplines (defined by years of enrollment in various high school subjects), and Piagetian cognitive level. One hundred eighteen-year old graduates of a suburban Central New Jersey high school were the subjects in this investigation. Three Piagetian tasks, the chemicals, balance, and permutations were administered to each subject to establish cognitive level.

Several results are of interest. Only 11 percent of the subjects were found to function at the fully formal level. More than half of the subjects were classified as early formal; the remaining 25 percent were classified as concrete. Of further interest is the finding that success on an individual task appears almost unrelated to success on another task. In the canonical analysis, the 14 independent variables yielded variate values of -.93 for the balance task, -.22 for the permutations task, and -.01 for the chemicals task. These tasks appear to utilize different cognitive processes.

Class rank is a function of grades. Rank, however, accounted for only 18 percent of the variance in cognitive level. Once the effects of rank and intelligence are controlled for in the analysis, neither the subject matter discipline nor the number of courses taken in a particular subject matter discipline have any significant effect upon individual cognitive level. Class rank and variables such as aptitude, achievement, and subject matter discipline representing virtually every objective measure of academic performance, collectively accounted for only 52 percent of the variance in cognitive level.

These results raise a number of questions about high school curricula, grading practices, and college placement procedures. The high school may emphasize cognitive functions other than those associated with formal thought. The number of courses taken in various subject matter disciplines appears unrelated to cognitive level. Higher correlations between both years enrolled in science courses and years enrolled in math courses with Piagetian cognitive level suggests that students with higher cognitive levels may select these disciplines over others. The high school may not influence cognitive development. Instead it may act as an academic filter. Students functioning at the higher cognitive levels selectively study science and mathematics.

COGNITIVE DEVELOPMENT IN SCIENCE ORIENTED STUDENTS

Robert N. Braun
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In the past decade there has been a widespread interest in the theory of cognitive development put forth by Jean Piaget. This interest has sparked a growing body of research on the effects which education may have on inducing or accelerating cognitive development. A number of studies (Griffiths, 1976; Kolodiy, 1975; Lawson, Nordland, and DeVito, 1975; among others) have reported that those who study science in high school and college perform at higher levels of cognitive development than do students studying other disciplines. These studies have led Fuller, Karplus, and Lawson (1977) to propose that the study of science can be used as a suitable vehicle to induce or accelerate a cognitive transition to higher levels of cognitive development.

In spite of this research, it remains unclear as to whether science is the vehicle which causes the display of higher levels of thinking; or whether, those who study science have a predisposition to this type of activity. For this reason, two samples of 'science-oriented' high school students were administered a battery of tasks. One sample, 30 high school freshmen, had not begun a formal study of science, but had indicated their interest in doing so. The other sample, 30 high school seniors, were completing their fourth year of high school science.

The subjects were individually administered five Piagetian tasks of formal operational thought (balance, shadows, inclined plane, colored chemicals, permutations). In addition, measures of cognitive ability (I.Q., vocabulary, and reading comprehension) and cognitive style (field dependence-independence) were obtained.

Subjects were assigned to one of the stages of Piagetian cognitive development on each Piagetian task, Chi-squared tests were used to compare the frequency distributions between the two samples. The ninth grade subjects were found to perform significantly lower than the twelfth grade subjects on only one task: the equal arm balance. The variables of cognitive style and ability were found to have no effect on cognitive development for either sample; although the scores for these measures were well above population values.

The results are interpreted as showing that in 'science-oriented' high school students, the higher levels of cognitive development are achieved before the students begin their formal study of science. The reason for this is unclear; but research with 'science-oriented' students, at younger ages, is clearly called for.

Fuller, R.; Karplus, R.; and Lawson, A. "Can Physics Develop Reasoning?" Physics Today, 1977, 30(2), 23-28.

Griffiths, D. "Physics Teaching: Does It Hinder Intellectual Development?" American Journal of Physics, 1976, 44(1), 81-85.

Kolodiy, G. "The Cognitive Development of High School and College Students." Journal of College Science Teaching, 1975, 5, 20-22.

Lawson, A.; Nordland, F. and DeVito, A. "Relationship of Formal Reasoning to Achievement, Aptitudes, and Attitudes in Preservice Teachers." Journal of Research in Science Teaching, 1975, 12(4), 423-431.

CONCURRENT SESSION I

INTERNATIONAL MEETING

Presiding: J. W. George Ivany
Simon Fraser University
Burnaby, British Columbia, Canada
V5A 1S6

Open meeting for all members interested in discussing matters of mutual concern.

RESEARCHERS POTPOURRI

Presiding: Arthur White
Ohio State University
Columbus, OH 43210

This open and unstructured time is provided for researchers with a common focus, from similar institutions, or a certain geographical area to plan or discuss research projects. Assemble your own group and make your own agenda.

CONCURRENT SESSION J

Session J-1 Instruction

Presiding: Judy C. Egelston-Dodd
National Technical Institute for the Deaf
Rochester, NY 14623

Factors Influencing Elementary School Student Teachers' Self Concerns

Claude H. Cunningham
Houston Independent School District
Houston, TX 70027
and
Jacob W. Blankenship
University of Houston
Houston, TX 77004

An Interventionist Strategy for Changing Teacher Behavior Based on Schwab's Levels of Openness

Marvin F. Wideen
David Hopkins
Simon Fraser University
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Effects of Activity Sequencing on the Acquisition of the Controlling Variables Schema

Jane B. Bowyer
Mills College
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and
Marcia C. Linn
Stanford University
Stanford, CA 94305

The Effect of Selected Analogies on Understanding of Scientific Explanations

N. Leonard Drugge
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and
Heidi Kass
University of Alberta
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FACTORS INFLUENCING ELEMENTARY SCHOOL STUDENT TEACHERS' SELF CONCERNS

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and

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Purpose

The purpose of this investigation was to determine which of a group of demographic and classroom variables were significantly related to elementary school student teachers' self concerns. Further, the study was designed to allow for documentation of elementary school student teachers' expressed needs for resolution of their concerns. The demographic variables considered were: 1) student teachers' ages and 2) the subject the student teacher thinks she teaches best. The classroom variables considered were: 1) teaching area, 2) class size, and 3) grade level taught.

Procedures

The sample consisted of 96 non-Black female undergraduate elementary education majors enrolled in student teaching through the University of Houston during the spring of 1974. Members of the sample were asked to respond to an altered form of the Teacher Concern Checklist—Form B (TCCL-B). The altered TCCL-B was designed to measure self concerns in three teaching areas: 1) concern for self as teacher, 2) concern for self as reading teacher, and 3) concern for self as science teacher. An open-ended needs statement was used to gather student teachers' expressions of need for resolution of their concerns.

The hypothesized relationship of the demographic and classroom variables to self concerns were tested using treatments by subjects analysis of variance, two-factor, mixed design analysis of variance, and one-way analysis of variance. Expressions of student teacher needs were categorized and need priorities established.

Findings

Teaching area and student teacher age were found to be significantly related to student teachers' self concerns. Class size was not found to be significantly related to self concerns. Grade level taught was not found to be related to self concern in any teaching area. The subject the student teacher thinks she teaches best was significantly related to concern for self as science teacher only.

Student teacher expressions of need were found to be predominately self-related needs. Categorization of these needs revealed two specific priorities for teacher educators. The first was the need for increased preparation in classroom management, especially as related to classroom discipline. The second was the need for establishment of procedures to insure an orderly orientation for student teachers to their student teaching assignments prior to the actual beginning of their student teaching experience.

Conclusions

Student teachers' self concerns were found to be significantly related to student teacher age and to teaching area. It was concluded that older student teachers' more varied experience background allowed them to be more successful and thus less self involved in classroom situations. It was further concluded that differences in self concerns related to teaching areas were reflective of curricular priorities at work in the student teachers' school rather than to student teachers' feelings of adequacy or inadequacy. Student teachers' expressed needs were self-oriented as predicted by the Teacher Concern Model. The types of needs expressed led to the conclusion that the members of the sample found student teaching to be a disquieting situation of which they had a faulty image.

AN INTERVENTIONIST STRATEGY FOR CHANGING TEACHER BEHAVIOR BASED ON SCHWAB'S LEVELS OF OPENNESS

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It has been argued that the curriculum reform movement of the sixties and early seventies was largely a failure in terms of affecting change in the behavior of teachers. Despite some notable exceptions, teachers teach much as they always have, through what Schwab has termed "a rhetoric of conclusions". One of the reasons for this is that while much effort was devoted to the development of programs and materials, little attention was paid to the complex problem of changing teacher behaviour (Dalin, 1977). It was assumed that providing in-service courses for teachers in the use of a program would in fact result in a different type of teaching pattern; however, this did not prove to be the case.

The need then would seem to be for more explicit interventionist strategies aimed at particular modes of teaching, easily communicated to teachers and designed to affect clear cut changes in teacher behaviour. The purpose of this paper is to describe the development of a strategy for teacher change based on Schwab's "levels of openness" (Schwab and Brandwein, 1962) and the use of that strategy in secondary classrooms.

The strategy involved an instrument based on Schwab's "levels of openness" and a plan; the latter was designed to affect behavioral change in teachers over a four-month period. The direction of the intended change was towards more inquiry-oriented behavior among teachers.

The instrument was a rating scale designed to produce a single measure of openness on a zero to four scale based on the summation of separate episodes. It could be used to rate a complete lesson or particular episodes depending on the specific topic. The basis for the rating was the level of openness involved in a particular laboratory or teaching episode. A value of 0.85 was obtained for the inter rater reliability between separate raters.

The plan included pre-taping to establish a base line for behavior, an intervention which involved providing models for alternative types of instruction and data feedback, and post taping to assess changes. Twelve elementary and five secondary teachers were involved, and each was considered as a separate case study in the analysis of change in teacher behaviour.

The results indicated that the instrument was a reliable, easy to use tool in the study of changes in teacher behaviour, and that the strategy was most effective in terms of shifting teachers towards the use of more open technique in their science teaching. However, shifts from one level to the next were accomplished only through a considerable effort, and subsequent observation revealed that a tendency existed amongst many teachers to revert back to pre-intervention patterns of behaviour.

The paper identifies these conditions as well as the factors relating to sustained change, and concludes with a discussion of the dynamics of intervention in classroom situations.

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EFFECTS OF ACTIVITY SEQUENCING ON THE ACQUISITION OF THE CONTROLLING VARIABLES SCHEMA

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The controversy between prescribed instructional sequences, individualized or personalized programs, and open education is largely unresolved. Gagne's theory has been associated with instructional programs in which tasks are logically ordered from the least to the most sophisticated. Piaget's theory has suggested many instructional procedures. One popular approach allows students to choose their own activities as in British open education. The current investigation compares the effectiveness of a hierarchically ordered activity sequence to one that is student selected. As a control, a randomly selected sequence was included.

This study is concerned with instruction in the application of the controlling variables schema as described by Piaget. Previous studies designed to teach controlling variables have generally been unsuccessful. The roles of cognitively prescribed sequencing and free choice have not been explored in this context. Research focusing on certain types of learning suggests that optimum sequences can be effective for specific tasks (for example, nonsense syllable learning); free choice sequences have motivational value (subjects are more likely to learn material they have chosen themselves). In addition, some research suggests that adults are better than children in selecting their own learning experiences, possibly because they are more familiar with the implications of their choices. Effects of three modes of activity sequencing on the acquisition of the controlling variables schema and student attitudes are explored in this study.

Methodology and Design

The activities used in each sequence were apparatus-based science experiences that one child could pursue independently. A total of 45 were available. Students first worked on a directed experiment with the followup option of designing their own investigations. An average of 40 minutes was spent on each activity. The order of the activities was made in one of three ways to achieve the goals of this study: (1) student-selected sequences, (2) student-assigned sequence designed by a Gagne trained psychologist to form a learning hierarchy, and (3) student-assigned sequence of randomly ordered activities.

The entire sixth grade class, consisting of 54 children from a racially and economically mixed urban school in northern California, participated in this study. Children were randomly assigned to "classes" of six students. Nine student teachers representing the total population of fifth-year credential candidates from a small private college, acted as the leaders. The student teachers were randomly assigned to each of the "classes," and to one of three conditions therein. Inservice workshops insured that all student teachers were familiar with the curriculum materials and classroom procedures. Each class met for one hour a week for twelve weeks in an empty book storage room located outside the regular classroom.

The program was evaluated using cognitive measures of controlling variables plus an attitude survey and measures of individual differences.

Instruments and Data

To measure understanding of the controlling variables schema, pre-post individual interviews were administered by experimenters not otherwise involved in the study. Tasks used were Bending Rods, Springs, Pendulum and Spinning Wheels, previously shown to have good internal reliability (r = .80) and validity. The attitude survey interview and group test were designed for this study. Measures of individual differences included Rod and Frame, Embedded Figures, Locus of Control, and Classroom Preference Inventory.

Results and Conclusions

Results of cognitive tests show overall gains from pre-test to post-test, but no significant differences between conditions. These results are similar to previous findings using only the free-choice condition. It seems likely that the novelty of an activity-centered program overshadows the differences between conditions.

Attitude survey results suggest that student attitudes toward the program are overwhelmingly positive. It appears that students prefer the mode of activity choice they are assigned to (i.e., the student-selected sequence classes prefer self-choice, and assigned sequence classes prefer teacher-choice). In addition, other systemic effects of conditions were noted.

THE EFFECT OF SELECTED ANALOGIES ON UNDERSTANDING OF SCIENTIFIC EXPLANATIONS

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The use of selected verbal and physical analogies in scientific explanations associated with kinetic molecular theory and explanations of the structure of matter and chemical change was investigated. A rationale was developed for the pedagogical use of analogies and it was hypothesized that the use of a verbal or a physical analogy in a textbook-like presentation or in classroom teacher demonstration will increase the students' immediate comprehension of the scientific explanation over that attained when the scientific explanation is presented without the use of one of these types of analogy.

This hypothesis was tested in three different experiments using 814 eighth grade students, 180 ninth grade students, and 1,258 tenth grade students. In all experiments one scientific explanation and its associated criterion test designed to measure the students' understanding of the scientific explanation were administered to each student. In the grade ten and grade eight experiments, the primary field of verbal analogy (in pre, post, within, side-by-side and advanced formats) accompanied the scientific explanations, except in the case of one group who received the postulates of the kinetic molecular theory and a control group who received only the scientific explanations. In total, 42 booklets were constructed to correspond to the 42 cells in the fixed effects factorial design (3 topics x 2 ranks x 7 treatments). In the grade nine experiment the primary fields of the two physical analogies were demonstrated to the experimental subjects.

The criterion mean scores of the experimental group administered the analogy and of the control group were compared. The null hypothesis was tested in five cases for concrete verbal analogies and in two cases each for conceptual verbal analogies and physical analogies. In no case did use of a concrete or a conceptual verbal analogy increase immediate comprehension over that of the control group. This finding was substantiated for boys vs. girls, the five formats, three topics, length of scientific explanation (between 150 and 815 words), grade levels, and levels of understanding of the analogy. Three treatment means were significantly lower than the corresponding control group means for concrete verbal analogies. This appeared to be a result of a topic x format x length of scientific explanation interaction.

When a physical analogy was used in a scientific explanation, immediate comprehension was significantly greater than that of the control group in one of the two cases. The scientific explanation for which there was a significant difference was the more complex of the two.

CONCURRENT SESSION J

Session J-2 Paper Set: Relating Research and Practice

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Piagetian Research in Science Education: Some Misgivings About its Potential to Improve Practice

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Conceptual Analysis: A Needed Dimension for Evaluating Science Curriculum Materials

Santos Mahung
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Determining Objectives Through Inquiry: A Critique of its Logical Basis

Graham W. F. Orpwood
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Second Thoughts About the Potential Influence of Science Teacher Education Research

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Classroom Observation in Science Education: The Potential of Ethnographic Research for Improving Practice

Brent S. Kilbourn
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Some Basic Questions About the Relationship of Knowledge to Action: Science Curriculum Development as a Case Study

Douglas A. Roberts
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PIAGETIAN RESEARCH IN SCIENCE EDUCATION: SOME MISGIVINGS ABOUT ITS POTENTIAL TO IMPROVE PRACTICE

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This paper is intended to be one of a paper set originating from a common concern about contemporary science education research. In this paper, a specific orientation in science education research is reviewed with the intent of showing that one might have reasonable misgivings about that orientation's potential to improve science education practice. The research orientation discussed here is that derived from the developmental theory of Jean Piaget which has generated a considerable amount of research activity within the NARST membership. (Six of the articles printed in Volume 13 of the Journal of Research in Science Teaching, and approximately one-fifth of the papers presented at the 1977 Annual Meeting in Cincinnati belong in this orientation.)

The misgivings that the present writer has about the potential of the Piagetian research orientation for improving practice can be grouped under two headings. Some examples are briefly stated below to illustrate the sorts of points contained in the paper itself.

1. Educational Claims

The Piagetian literature contains significant claims about educational practice. Some of these, though, pose concerns. For example, it is said that active manipulation is important for concept development, yet Anthony (1977) suggests that this may not be so. Also, it has been claimed that teaching could be organized to reflect the developmental stages, but Kaufman and Konicek (1974) have questioned that such a procedure can assist the child to construct psychologically his reality. These and other issues are discussed to reveal the tentative relationship between the theory itself and teaching practice.

2. Metatheoretical Considerations

A number of recent works raise questions about some of the concepts in Piaget's theory. An examination of these reveals that there is cause for some misgivings, despite the obvious and vast contribution which the theory makes to our understanding of intellectual development. For instance: Smedslund (1977) is doubtful of the explanatory usefulness of the concept decalage; Ennis (1975) has indicated concern for the normative character of Piagetian logic; and Toulmin (1971) has examined problems tied to Piaget's concept of stage.

Discussions of these two areas leads to a consideration of how the Piagetian research orientation in science education could be related to professional practice, with particular reference to curriculum and instructional planning, and to the diagnosis of children's learning. It is suggested that, in light of these misgivings, it might be useful to consider an alternative for planning and diagnosing. The paper shows how a conceptual or philosophical analysis of what is to be learned and of children's learning itself can inform curriculum design and provide explanations about learning in a way which might satisfy some needs in professional practice.

Anthony, W. S. "Activity in the Learning of Piagetian Operational Thinking." British Journal of Educational Psychology, 1977, 47, 18-24.

Ennis, R. H. "Children's Ability to Handle Piaget's Prepositional Logic." Review of Educational Research, 1975, 45, 1-41.

Kaufman, B. A. and Konicek, R. D. "The Applicability of Piaget to Contemporary Curriculum Reform." Paper presented at the annual meeting of the National Association for Research in Science Teaching, Chicago, 1974.

Smedslund, J. "Piaget's Psychology in Practice." British Journal of Educational Psychology, 1977, 47, 1-6.

Toulmin, S. E. "The Concept of 'Stages' in Psychological Development." In T. Mischel (Ed.) Cognitive Development and Epistemology. New York: Academic Press, 1971.

CONCEPTUAL ANALYSIS: A NEEDED DIMENSION FOR EVALUATING SCIENCE CURRICULUM MATERIALS

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This paper is intended to be one of a paper set originating from a common concern about contemporary science education research. It proposes to look at conceptual analysis, its methodology and potential, as a systematic dimension in the evaluation of science curriculum materials.

The literature on science curriculum materials evaluation can be divided into three categories. In the first are reports of empirical studies—a search for objective evidence—evaluating the success or failure of materials to achieve selected objectives which are observable or directly measurable. Also included in this category are discussions of methodology employed in such studies, the advantages and pitfalls. This kind of study usually has its basis in a psychological frame of reference—especially in models of learning as behavioral change.

In the second category are articles, and even books, actually describing and promoting a particular instrument for evaluating curriculum materials. The work of Haussler and Pitman (1973) and that of Ben-Peretz (1977) are examples. Studies based on the instruments differ from those of the first category in that pupil achievement is not assessed. Instead, the instruments are designed for analysis of materials, and are best described as *functionally descriptive*. Thus, use of the instruments is generally limited to qualitative analysis, that is a description of the materials or program—an identification of the features of the materials. Certain desirable characteristics are identified as present or absent; e.g., objectives stated behaviorally, rationale presented clearly, and content organized properly. The basis for determining what characteristics are desirable lies mainly in a psychological frame of reference or in general curriculum theory; e.g., a Bloom-Tyler model for curriculum. These instruments seek wide applicability by containing the "analysis" within a greater descriptive framework. The desire to incorporate wide applicability into the features of the instruments constrains the instruments to a generally descriptive role. Thus, the instruments are not designed for and therefore not capable of being used for *critical conceptual analysis* of materials.

The third category includes those articles which move from the specific to the general. The discussion here is at a meta-level about evaluation and, although it may focus on the concerns of the first two categories, the intent is to suggest an approach or attitude towards evaluation rather than championing a particular instrument or reporting a single study. This is the category in which this paper is intended to be included.

There is only minimal reference in this third category to the use of critical conceptual analysis in the evaluation of curriculum materials. Although the possibility for the use of conceptual analysis has been recognized and it has been used, the approach remains largely unrecognized for its evaluative potential. Westbury (1970), for one, has recognized the possibility; Marshall Herron (1971), for one, has used the approach. Perhaps the reason for lack of more widespread recognition is the general paucity of explications of the methodology and potential of this approach. Whereas the limited use of conceptual analysis for evaluation of curriculum materials has been directed towards evaluating materials within the constraints of their stated goals (an important use of itself), the approach opens up a whole new way of looking at curriculum materials in a systematic fashion. It provides a way of looking at the internal consistency of materials with respect to program goals and the provisions made for achieving these, as well as unspecified outcomes and meta-lessons which can potentially occur from the use of the materials. These are important to know not only in deciding whether to adopt the materials, but also in assessing their impact if adopted.

Ben-Peretz, Miriam. "Curriculum Analysis Matrix." 1977. (Mimeographed.)

Haussler, Peter and Pitman, June. A Curriculum Material Analysis System for Science. Beltz Verlag, 1973.

Herron, Marshall D. "The Nature of Scientific Enquiry." School Review (February 1971), 171-212.

Westbury, Ian. "Curriculum Evaluation." Review of Educational Research, 1970, 40(2), 239-260.

DETERMINING OBJECTIVES THROUGH INQUIRY: A CRITIQUE OF ITS LOGICAL BASIS

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This paper is intended to be one of a paper set originating from a common concern about contemporary science education research. More specifically, it addresses the problem of the relationship of empirical research to the determination of the objectives of science teaching.

The hope that the objectives of education could be discovered by a process of empirical inquiry has long been cherished by curriculum developers—in science education as elsewhere. Although the focus of research aimed at this goal has varied over the years, the pattern of reasoning associated with it has remained essentially the same: "Research has shown that X; therefore, science programs ought to pursue objectives a, b, and c." Expressed in still more general terms, the argument represents a move from warranted knowledge, established by research, to prescriptions for action. This paper is an inquiry into the defensibility of such a move.

Research studies aimed at the determination of objectives are found in a variety of areas. They include studies of learners, of teachers, studies into the subject matter, and into the wider social context of education. For the purposes of this summary, studies of learners can serve as exemplars. These include, on the one hand, investigations into the learner's needs, his interests, his abilities, his likely vocational goals; such studies provide knowledge in a direct way about specific groups of learners. On the other hand, there are studies aimed at more generalizable conclusions: into how learners learn, into what social or instructional factors are related to the learner's achievement, and so on. In either case, the studies are intended to yield knowledge about learners. Insofar as this knowledge is used as the basis for the determination of objectives, researchers have argued that the objectives of science programs ought to correspond in specific ways to such knowledge. Examples from recent research papers are used to illustrate this point.

In this paper, these approaches to the determination of science education objectives are criticized from the perspective of the logical requirements of what is known, technically, as "practical reasoning." It is an established principle of practical reasoning that arguments for a course of action must proceed from a premise embodying a value position, and cannot rest on empirical evidence alone. It is inappropriate, therefore, to argue solely from research evidence that certain objectives should be pursued in science education. For example, suppose that in a particular location, it were an established piece of knowledge that all graduates of the school system became farmers on graduation. In that situation, one could *not* argue without further ado that the objectives of the science program ought to emphasize agricultural topics; such an argument would violate the principles of practical reasoning.

The paper thus has three objectives. It identifies the predominant value positions underlying representative research attempts to determine objectives. It relates the importance of these value positions to the conduct and outcomes of the research studies. And finally, it offers an alternative conceptualization of the process of choosing objectives—one that is logically consistent with the nature of the task and that also clarifies the function of warranted knowledge (and of the research designed to generate such knowledge) in the process.

SECOND THOUGHTS ABOUT THE POTENTIAL INFLUENCE OF SCIENCE TEACHER EDUCATION RESEARCH

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Has research in science teacher education made a difference, either in the ways we conduct preservice and inservice science teacher education or in the ways participating teachers teach? "Not very much" seems to be the appropriate answer when this question is addressed to many contemporary studies in this area of science education. The purpose of this paper is to illustrate and suggest possible explanations for this state of affairs, and to indicate research alternatives which seem to hold greater promise for improving practice.

We are faced, fundamentally, with the question of what basic criterion to use to judge our research. Like much research in science education in general, many instances of research related to the education of science teachers seem to be guided by the criterion that the research be "scientific." Thus the form of research is the important feature: independent and dependent variables, control groups, statistical analysis of numerical data, and acceptance or rejection of hypotheses.

When we restrict ourselves to research in this form, we limit the kinds of questions we can ask and we limit ourselves to particular kinds of results. Accordingly, we may ignore some of the most important questions of science teacher education practice, and then, when we do have our results, we may limit their potential influence because they are so difficult for others to translate into changed practices. In science teacher education and in science teaching at the elementary and secondary levels, current practices have enormous momentum, maintained in part by the very powerful nature of learning by modeling. Our potential influence is severely restricted if our questions and our results ignore that momentum of current practice.

The first part of the paper presents examples of contemporary science teacher education research, asking of each how significant the question is and to what extent the results achieved may be expected to improve science teacher education practices. It is argued that the potential influence of the research is, in many cases, unduly restricted by the format of the research and by the implied assumptions about how science teachers and science teacher educators evaluate proposals for the improvement of practice.

The second part of the paper examines alternatives to the most familiar form of science teacher education research, again looking at the significance of questions and the potential influence of results.

Here reference to specific examples is particularly important, to illustrate in practical terms the nature of specific alternative research modes. No claim is made or intended to the effect that all the alternatives in use or in development have been identified. Rather, the goal is to encourage consideration of alternatives to the predominant mode of contemporary research in science teacher education. When a mode of research seems to persist not because it informs and influences practice but because it is the traditional mode and appears to be scientific, second thoughts are inevitable and deserve our serious consideration.

CLASSROOM OBSERVATION IN SCIENCE EDUCATION: THE POTENTIAL OF ETHNOGRAPHIC RESEARCH FOR IMPROVING PRACTICE

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This paper is intended to be one of a paper set originating from a common concern about contemporary science education research. The first part of the paper will outline the conditions which must be met if research is to have promise for improving practice. An argument will be developed that practice can be improved only when research attends to the particulars of a given classroom setting—this particular teacher, with these particular students, and this particular environment. That is, at the level at which we customarily talk about the improvement of classroom practice it is necessary to base decisions and action on specific details of the interaction. These specific details form the context in which events in the classroom are understood by students and teachers, they determine the success of teaching, and they are unique to each classroom.

The second part of the paper will be the critical appraisal of research involving science classroom observation. The intent is to articulate, through examination of selected studies, the general orientation or paradigm guiding current observational research. The research paradigm(s) will be analyzed in light of the above argument. The effort will be to see if there are inherent limitations of the paradigm that work against significant improvement of practice. In this portion of the paper there will be a discussion of the place of research geared toward a search for empirical generalizations.

The final portion of the paper will explore the usefulness of ethnographic research for contributing to the improvement of practice. Such research deals specifically with the particulars of the classroom and consequently might have a relatively high chance of informing practice in significant ways. It will be argued that ethnographic research be undertaken not in lieu of, but in addition to, other observational research paradigms.

SOME BASIC QUESTIONS ABOUT THE RELATIONSHIP OF KNOWLEDGE TO ACTION: SCIENCE CURRICULUM DEVELOPMENT AS A CASE STUDY

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This paper is intended to be one of a paper set originating from a common concern about contemporary science education research. Specifically, the present paper has two purposes: to deal with general matters exemplified in all six papers, and as well to focus on one area of science education research according to the themes common to the papers.

These six papers deal with the problem of conceptualizing an appropriate role for knowledge in the improvement of science education practice. Recognizing a distinction as old as Aristotle, but recently revived and elaborated by Schwab in the context of curriculum, the authors have taken note that knowledge production in the field of science education—the function of researchers—has a radically different character than that of practical action in the classroom—the function of presumed consumers of research. Research is in the Aristotelian category of human affairs known as "the theoretic," while practice is in the category known as knowledge; those in the practical eventuate in defensible decisions. Ground rules for the theoretic demand that generalizations be sought; ground rules for the practical insist that this particular be dealt with. The complexity of intellectual life (in the theoretic) requires abstraction of selected attributes of the phenomena being studied; some attributes *must* be ignored. The integrity of decision-making life (in the practical) requires that the phenomenon be dealt with in its wholeness; no attributes *can* be ignored.

Given this overarching viewpoint, it is clear that research findings in science education will be related to science education practice in highly complex ways. Yet, two simplistic views seem to prevail about that relationship. At the one extreme one finds a "knowledge-consuming" view, which envisages the practitioner waiting patiently for each new issue of JRST in order to know how to improve practice. At the other extreme one finds a "knowledge-ignoring" view, basically anti-intellectual in its posture (and seeing as large the uniqueness of MY situation, compared to that of THEIR study). Neither view is satisfactory, and the six papers of this set seek to formulate a more realistic role for knowledge in the determination of action.

Six areas of science education research will be examined in the total paper set. For purposes of developing and exemplifying the general overarching issues raised in this paper, selected literature on curriculum development in science (and, to a limited extent, in general) will be analyzed.

CONCURRENT SESSION J

Session J-3 General Research

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Quantitative Indices for Cognitive Structures

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The Development and Validation of a Diagnostic Test of Metric Skills

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Development of the Image of Science and Scientists Scale: Classical and Rasch Model Approaches

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Attitude Formation in Introductory Science Courses: An Application of Dissonance Theory

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QUANTITATIVE INDICES FOR COGNITIVE STRUCTURES

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The degree of similarity between a learner's cognitive structure (i.e., his or her internal organization of concepts in memory) and the appropriate subject matter structure has received much attention in the recent educational literature (Shavelson, 1973, 1974; Preece, 1976; Johnson, 1967). Preece, for example, noted that the degree of similarity of a student's cognitive structures to the appropriate subject matter structures could be a useful criterion measure in experiments to evaluate or compare teaching methods. Two as yet unsolved problems are (1) what index should be used in comparing student response structures and "correct" structures and (2) what cognitive abilities, if any, aid in the acquisition of correct structures. This paper seeks to provide answers to these two questions.

Previous investigators have typically sought to compare structures by examining the differences between matrices of semantic proximity between all concepts in a given set. That is, the method involves obtaining direct similarity estimates from students between all $\binom{n}{2}$ pairs of n concepts or words in a given set and then comparing the resultant n x n similarity matrix to the "correct" similarity matrix. Another method requires students to build di-graphs where points in the graph represent words and lines represent the relationships among the words. The student is further instructed to rank order the relationships by placing ranks on each line. Multidimensional scaling analyses of these matrices has generally proven not to be meaningful. Moreover, the Euclidean distance analysis suggested by Shavelson (1974), wherein the Euclidean distance between transformed student matrices and the correct matrix is used as an index of structural similarity, was found to be inadequate by Preece because such distances reflect not only different patterns of cell entries, but also their absolute distances.

The use of similarity matrices in comparing structures is questionable for two reasons. First, the notion of similarity is inappropriate for many subject matter domains (e.g., biological phyla are hierarchical structures which are best represented by having students actually construct the hierarchy). Second, the number of similarity estimates for n concept words increases exponentially with increasing n, rendering many studies impractical. In the present study, simple indices are developed from the adjacency matrices representing student-generated graphs. The indices were found to increase linearly with increasing departure from "correct" matrix representations. Additionally, the indices correlate as predicted with scores on the Shipley test of mental operations and with scores on a multiple choice in the relevant subject matter.

Seventy-two seventh and eighth grade students were given a pre-instruction task involving 13 rock terms from elementary geology (rock, sedimentary, igneous, metamorphic, pumice, sediment, lava, granite, shale, magma, slate, marble, and limestone). The students were given 13 cards on each of which was printed one of the rock terms and were instructed to arrange the cards so that they "made sense," that is, they conveyed to the student meaningful information. An example using the terms *insect*, *thorax*, *abdomen*, *head*, *eyes*, *antenna*, *legs*, and *spiracles* was demonstrated by the experimentor. When the student was satisfied with the arrangement, he or she was instructed to write the words on a sheet of paper with lines indicating the relationship between the concept words. For example, with the insect terms the experimentor drew three lines connecting *insect* to *thorax*, *head*, and *abdomen*. The students were also administered a 33-item objective test in elementary geology and the Shipley Test of mental operations.

On successive days following completion of the above tasks, all students read two, four, and eight-page readings in basic geology taken from standard texts, after which the card sort activity and the multiple choice test were re-administered.

The deviation of the response card sort (M_i) for each student ($\underline{i}$) from the correct card sort (M) was quantified by computing three simple scalar quantities from the deviation matrix $D_i = M_i - M$. Matrix $M_i = C + C^2$ where C is an adjacency matrix with

$c_{ij} = 1$ if a line connects words $\underline{i}$ and $\underline{j}$

$c_{ij} = 0$ if no connection exists.

Matrix C^2 is the two-stage communication matrix with

c^2_{ij} = the number of directed paths in the structure connecting words $\underline{i}$ and $\underline{j}$ in two steps

The first index, L_i, is the log of the marginal column sum of the D matrix for each student as follows:

$$L_i = \log \left(\sum_i^n \sum_i^n d^2_{ij} \right) \quad , n = 13$$

The second index, P_i, is simply the number of zeroes in the D_i matrix. The third index, T_i, a measure of how interrelated student $\underline{i}$ perceives the words to be, is the trace of the D_i matrix.

A summary of the results readily indicates the utility of these simple indices of cognitive structure. While approximately 25 percent of the variance in post test scores was explained by the pretest, fully 46 percent of the post test variance was explained by L_i (i.e., the linear correlation between L_i and post test was -.68). Moreover, L_i correlated -.50 with residualized post test scores. Of significance also is the fact that the partial correlation between L_i and the post test (pre test partialled from both) is -.60, a correlation which is only slightly below the zero order r between these two variables. A very similar pattern of relationships exists between P_i and post test scores, with signs reversed. Index T_i however showed no discernible pattern of correlations with post test scores. The above pattern of correlations suggests strongly that performance on typical classroom tests of a given subject matter is directly correlated with the extent to which a student's internal organization of concepts in the subject matter maps onto the correct organization of those concepts.

While the question "What cognitive abilities aid students in correctly representing subject matter structures?" will require further study, the present study suggests several abilities for further investigation. The authors predicted, for example, that total score on the Shipley test would correlate positively with P_i and negatively with L_i. This prediction was borne out, the relevant correlations being .52 and -.49, respectively. Additionally, the two subscales of the Shipley which appear to be most relevant (viz., *Class Inclusion*, defined as the use of diverse attributes as criteria for grouping, or schemes of combination with one class included in another, and *Transfer*, defined as the ability to recognize order relationships through indirect comparisons of inequalities) in fact correlated significantly with both L_i and P_i.

Johnson, P. E. "Some Psychological Aspects of Subject Matter Structure." *Journal of Educational Psychology*, 1967, *53*, 75-83.

Preece, P. F. W. "A Note on the Comparison of Cognitive Structure and Subject-Matter Structure." *Journal of Research in Science Teaching*, 1976, *13*, 353-354.

Shavelson, R. J. "Learning from Physics Instruction." *Journal of Research in Science Teaching*, 1973, *10*, 101-111.

Shavelson, R. J. "Methods for Examining Representation of a Subject-Matter Structure in a Student's Memory." *Journal of Research in Science Teaching*, 1974, *11*, 231-249.

THE DEVELOPMENT AND VALIDATION OF A DIAGNOSTIC TEST OF METRIC SKILLS

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With a few notable exceptions, metric education in North America appears to be making erratic progress. Public opposition is greater than previously expected, and conversion problems are often complex. As metric educators meet these problems, there develops a need for a criterion referenced evaluation instrument which can diagnose specific weaknesses and also assess the degree of mastery of the metric system.

The criteria upon which the test items are based arise from a set of hierarchies of metric skills formulated using the task analysis techniques of Robert Gagne. Separate hierarchies were developed for each of four general skill areas: (1) Knowledge of Units and Symbols, (2) Estimation Skills, (3) Measurement Skills, and (4) Conversion Skills. Using length, volume, mass, and temperature as content variables, the following table of specifications was established. Numbers indicate the number of items per cell.

Table of Specifications

Content	Skills				
	Units and Symbols	Estimation Skills	Measurement Skills	Conversion Skills	Totals
Length	5	3	3	3	14
Volume	4	4	5	5	18
Mass	3	2	2	3	10
Temperature	0	3	2	1	6
Totals	12	12	12	12	48

The items used were selected from a large pool of items that were pilot tested in grades four through seven. Pilot testing included performance tests in estimation and measurement skills, and only those multiple choice items which correlated well with the performance results were used in the final instrument.

Construct validity was determined using a panel of metric experts who also matched individual items to the hierarchies of metric skills. The McFee Metric Test was also administered in order to obtain a measure of concurrent validity (r = 0.71). Reliability was determined using a split-half reliability coefficient (r = 0.86).

The final instrument was administered to a random sample of 262 fifth and sixth grade students from 26 schools in the cities of Spokane and Calgary as part of a comparative study in metric education. Forty-six teachers also completed the test as part of the study. An analysis of the results indicated an average item difficulty of 0.46 with most items falling between 0.2 and 0.7. Using a phi coefficient to determine discrimination, 41 of the 48 items were above 0.3. Student scores ranged from 9 to 37 with a mean of 22. Teacher scores ranged from 23 to 45 with a mean of 36.

Results of the test can be analyzed for each of the four skill areas and also for each of the metric measuring units. In order to keep the length of the test manageable, the number of items in each cell of the table of specifications is not sufficient to yield further reliable diagnostic information.

The test instrument is suitable for use with grade 5 students through to adults, but is generally designed for intermediate grade students. The 48 items can be completed in about 15-20 minutes.

DEVELOPMENT OF THE IMAGE OF SCIENCE AND SCIENTISTS SCALE: CLASSICAL AND RASCH MODEL APPROACHES

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The Image of Science and Scientists Scale is a 48-item, Likert-type instrument measuring the respondent's opinions or attitudes toward ("image of") the field of science and scientists as professionals. The scale was developed from work done in the fifties by Mead and Metraux (1957). The scale was administered to two samples of respondents under somewhat different conditions. In the first administration, 378 seventh through twelfth grade students responded to 50 statements in a dichotomous (agree-disagree) fashion. These responses were analyzed in a classical fashion and using the Rasch model of item analysis. Two items were deleted on the basis of the analysis and several were modified. Then 408 ninth grade students responded to the items on a six-point Likert scale. These responses were also analyzed using the classical test analysis and Rasch model latent trait approach. In the second administration, students also took the Group Embedded Figures Test; IQ scores and science grades were recorded for this group.

The paper compares item analysis and instrument development for the two test models and for dichotomous vs. Likert responses. Additionally, the relationships among field dependence/independence, IQ, science attitude, and science grades are examined using Rasch scoring and Likert scoring. While the focus of the paper concerns the comparison of the classical and Rasch test models in affective instrument development, test statistics from both models indicate the practical usefulness of the Image of Science and Scientists Scale.

Mead, Margaret and Metreaux, Rhoda. "Image of the Scientist Among High School Students." Science (August 1957), 126, 385-390.

ATTITUDE FORMATION IN INTRODUCTORY SCIENCE COURSES: AN APPLICATION OF DISSONANCE THEORY

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Objectives and Theoretical Rationale

Four theoretical bases have been recently proposed by NARST researchers investigating attitude modification:

a. cognitive dissonance
b. perceptual theory
c. communication theory
d. functional approach

Of those theories, cognitive dissonance appears to offer a rather appealing framework for understanding the intricacies of attitude formation by students enrolled in introductory science courses at both the high school and college levels. Unlike second and third level courses in a particular science area, introductory (or first level) courses appeal to a wider variety of students, attracting people with diverse interests and career objectives.

Festinger (1957) in *The Theory of Cognitive Dissonance* postulates that two cognitions—things a person knows about himself, about his behavior, and about his surroundings—can exist as irrelevant or relevant relations. Two cognitions are irrelevant when one implies nothing concerning the other, a rather unlikely situation when the two cognitive elements are knowledge of one's enrollment in an introductory science course and the extent of successful (or non-successful) experiences in the course. On the other hand, if the two cognitions are relevant, then the overall relationship between them lies somewhere along a consonant-dissonant continuum. The degree of consistency or inconsistency (consonance or dissonance) depends upon the elements comprising the cognitions.

The purpose of this proposed paper is to offer some possible answers to the following questions using cognitive dissonance as a theoretical basis:

-- What are some of the elements which possibly comprise each of the cognitions?
-- How are the cognitions rendered relevant and irrelevant?
-- What are the effects of dissonance between the two cognitions?
-- How can dissonance be either avoided or reduced?

Methodology and Design

After a brief overview of Dissonance Theory, possible answers to the preceding questions will be presented. Relationships between the two cognitions, elements comprising the cognitions, and courses of action available as a result of dissonance will be discussed. Evidence is to be reviewed which supports further research into dissonance theory as a theoretical basis for attitude formation in introductory science courses.

Instruments and Data

Results of a research report recently published by this investigator noted that students (N = 22) who learned in preferred ways registered a more positive change in their attitudes toward two introductory college physics courses in which they were enrolled than did their counterparts who learned in ways they did not prefer. Learning preference was measured using the Structural Compatibility Inventory (SCI); attitudes toward physics using the Subject Preference Scale (SPS). At the time of this investigation physics achievement data (final course grades) were collected, thus providing information as to the success of each student enrolled in the courses.

Results and Conclusions

Course preference was not found to be related to physics achievement. Likewise, achievement in physics (as measured by course grades) was not found to differ between students learning in preferred ways and those not learning in preferred ways. Satisfaction with physics (as measured by SPS) did, however, differ between the two groups. Students learning in ways they preferred registered a more positive change in preference for physics than did those learning in ways not preferred.

In the context of dissonance theory attitude can be defined as a predisposition to make an evaluative response based upon the relationship between two cognitions. In terms of the two previously mentioned cognitions, dissonance is experienced by students enrolled in an introductory science course in which they feel unsuccessful. Acquiring a negative attitude toward the physics course—a condition more consistent with the lack of success—represents a natural move on a student's part to reduce dissonance by reducing the importance of achievement in physics. When students are provided with instructional experiences compatible with the manner in which they prefer to learn, dissonance is reduced; learning in preferred ways is consistent with having a successful experience in the course. Course attitude is thereby improved as the negative effects of achievement are somewhat counterbalanced.

Suggestions are to be made for the development of an instrument which will access the extent to which achievement, method of instruction, and the instructor influence students' attitude toward a science course.

Festinger, L. *The Theory of Cognitive Dissonance*. New York: Harper and Row, 1957.

CONCURRENT SESSION J

Session J-4 Curriculum Development and Evaluation

Presiding: Carl Naegele
Michigan State University
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An Achievement and Attitudinal Comparison of an Elective Mini-Course Science Curriculum and a Conventional Non-Elective Science Curriculum at the Junior High School Level

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An Analysis of Laboratory Activities in Two Modern Science Curricula: Projects Physics and PSSC

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Science Curriculum Selection Criteria as Discriminated by Decision Makers, Change Agents, and Curriculum Developers/Publishers

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Using Qualitative Data in Formative Evaluation

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AN ACHIEVEMENT AND ATTITUDINAL COMPARISON OF AN ELECTIVE MINI-COURSE SCIENCE CURRICULUM AND A CONVENTIONAL NON-ELECTIVE SCIENCE CURRICULUM AT THE JUNIOR HIGH SCHOOL LEVEL

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Rationale and Objectives

During the last decade curricular revitalization to achieve individualization and relevance has included science programs that offer student electives in the form of "mini-courses."

It appears that the idea of the elective mini-course curricula will continue to expand in the years ahead as an alternative instructional approach. In view of the apparent lack of published and scientifically oriented studies denoting the effectiveness of mini-courses, several questions are pertinent at this time. Are the elective mini-course programs better than what had been taught previously? Does the new approach make a difference in student achievement? Are there students for which an elective program results in greater achievement or a better attitude toward science? What effect does a random ordering of courses have upon student learning? Are the attitudes of students toward science affected as a result of the elective programs?

Obviously, the recent rapid growth of elective programs must be recognized. The answers to these questions would be most helpful in justifying their continued growth and to assist in building better curricula and improving instruction. A comparative study, between a school utilizing a science elective curriculum and one using a conventional textbook program was completed to hopefully provide answers to such questions by measuring gains in student achievement and attitude. In retrospect, different instructional approaches were utilized in the two schools to teach similar course content.

Methodology and Design

A longitudinal study utilizing a "Nonrandomized Control-Group Pretest-Posttest Design" was employed. The experimental and control groups consisted of grade 7 and 8 science students at two junior high schools in a suburban Pittsburgh, Pennsylvania school district. The statistical similarity of the two student populations was confirmed by data from a socio-economic survey and by comparing the group intelligence scores.

The investigation was conducted during the course of the complete 1975-1976 school year.

Instruments, Data, and Results

The Test of Science Knowledge (TOSK), Part II, was administered at the beginning of the school year in September, 1975, and repeated at the termination of the course in June, 1976, as a criterion measure to determine the amount of mean achievement gains. A Scientific Attitude Inventory was also administered as a pretest and posttest measure to assess gains in scientific attitudes of the students in each treatment. The effects of non-sequential and sequential presentation of subject matter upon cumulative mean achievement gains was monitored also by administration of the Cooperative Science Tests, General Science, forms A and B, to each grade at nine-week intervals. A "Three-Factor Mixed Design: Repeated Measures on One Factor" was utilized to obtain the gain scores analyses.

Aptitude-Treatment Interactions (ATI) were studied also as the basis for determining what effect various personological variables have upon student achievement and attitude in both of the programs. In this study, the personological variables were grade level and sex as a function of mental ability upon the achievement and attitude criterion measures. All possible combinations of grade level and sex were studied for both the experimental and control groups. Simple regression equations were utilized to test the slope of the pairs of regression lines for the existence of aptitude treatment interactions at each level.

The .05 level of significance for rejecting or not rejecting the null hypotheses for equality of population means and homogeneity of regression equations was utilized in the data analysis.

Conclusions

The mini-course elective program, as an alternative approach to science instruction at the junior high school, has demonstrated limited success.

1. There was no significant difference in mean achievement or attitude gain scores between the schools, and

2. There was no significant relationship between achievement or attitude scores and general ability across the experimental and control groups for students of different sex or grade level.

AN ANALYSIS OF LABORATORY ACTIVITIES IN TWO MODERN SCIENCE CURRICULA: PROJECT PHYSICS AND PSSC

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and

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Laboratory activities in the "new" curricula of the 1960's were supposed to lead students into problem solving and scientific thinking, into inquiry and independent investigation. Yet Shulman and Tamir (1973), following criteria developed by Schwab (1962) and Herron (1971), have pointed out that the overwhelming majority of laboratories at schools using the "new" curricula were still providing students with the definition of a problem, giving them a set of procedures to follow, and often giving them a key against which to check their answers. While several recent studies have attempted to analyze the kinds of instruction occurring in the laboratory, no attempts to follow and to refine the kind of analysis of laboratory manuals performed by Herron (1971) could be found in the literature.

Are the laboratory guides for Project Physics (1970) and for PSSC (1971) consistent with the goals of their designers? Do they reflect appropriate attention to scientific inquiry? The purpose of this study has been to:

1. develop a refined scheme for the quantitative analysis of science laboratory investigations;

2. analyze and compare the laboratory activities in the third edition of the PSSC Laboratory Guide and the Project Physics Course Handbook according to the proposed scheme;

3. discuss the implications of the analysis for instruction and for curriculum development in physics.

A 20-item task-analysis instrument and a 6-item instrument to identify the integration of laboratory work with other components of the course were developed. The tasks were formulated in terms of the inquiry skills and actual behavior required to perform the prescribed laboratory work. Frequency counts were compiled for each experiment and unit in the PSSC course and in the Project Physics course.

Differences in orientation between the PSSC Laboratory Guide and the Project Physics Handbook are not as easy to detect from the results of this analysis as might have been expected. However, the following conclusions are clear:

1. The task analysis instrument and the organization instrument are of use in the analysis of science laboratory manuals generally and physics laboratory manuals in particular.

2. Laboratory work in both PSSC and Project Physics does play a central role in the two physics courses. Students actually perform and manipulate materials, gather qualitative as well as quantitative data, make inferences and generalizations, and communicate the results of their activities in a variety of commonly accepted ways.

3. Five important deficiencies were identified: a) students do not engage in identifying and formulating problems or in formulating hypotheses; b) students have relatively few opportunities to design observation and measurement procedures, and even fewer opportunities to design experiments and to work according to their own design; c) students are not encouraged to share their efforts in laboratory investigation where sharing might be appropriate; d) explicit provisions do not currently exist for post-laboratory discussions to facilitate understanding the implications of findings.

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Herron, M. D. "The Nature of Scientific Enquiry." School Review, 1971, 79, 171-212.

Physical Science Study Committee. Laboratory Guide. Lexington, Massachusetts: Heath, 1971.

Schwab, J. J. "The Teaching of Science as Enquiry." In J. J. Schwab and P. F. Brandwein, The Teaching of Science. Cambridge, Massachusetts: Harvard University Press, 1962.

Shulman, L. S. and Tamir, P. "Research in Teaching in the Natural Sciences." In R. M. W. Travers (ed.), Second Handbook of Research on Teaching. Chicago: Rand McNally, 1973.

SCIENCE CURRICULUM SELECTION CRITERIA AS DISCRIMINATED BY DECISION-MAKERS, CHANGE AGENTS, AND CURRICULUM DEVELOPERS/PUBLISHERS

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In order that the greatest number of viable options of science curricula are available to local decision-makers, a common set of selection criteria which articulates the needs of the user, producer, and disseminating agent must be found. This will facilitate the function of an information delivery system as it provides the curriculum options for decision-makers.

This research focused on the criteria for kindergarten through twelfth grade science curriculum selection as discriminated by local decision-makers, change agents, and curriculum developers/publishers.

The specific questions addressed in the study were: (1) What are the ten most important science curriculum selection criteria as ranked separately by: decision-makers, change agents, and curriculum developers/publishers?; (2) What are the significant differences among the four United States geographic regions in their ten most important criteria for science curriculum selection as ranked by: decision-makers and change agents?; and (3) What are the significant differences among the three groups' perceived value of science curriculum selection criteria from the ten most important as ranked by decision-makers, change agents, and curriculum developers/publishers?

To find the answer to these questions, a two-part survey was designed, piloted, and then mailed to 725 individuals, using a systematic sampling procedure. The instrument was composed of a demographic data sheet and a list of 25 validated criteria. The respondents chose the "most important ten" and ranked them. Space was provided for the inclusion of other criteria not mentioned in the list. A total of 347 usable instruments, or 48 percent of the sample, was returned. A nonrespondent survey validated that the relatively large number of nonrespondents in the original survey were similar in their discrimination among the curriculum selection criteria.

The data were quantified and weighted means, analysis of variance, and Scheffe's Multiple Comparison procedures were used in analyses of the data. All tests of significance were made at the α level of $p < .10$.

Conclusions of the Research

There is a common set of eight criteria which have been selected by decision-makers, change agents and curriculum developers/publishers. They are:

- *Approach* (e.g., concept, process inquiry, discovery, discipline-centered, lecture)
- *Scope*, i.e., depth or focus of *entire* curriculum
- *Sequence*, i.e., pattern or structure of curriculum with each grade level
- *Student-learning objectives* or outcomes stressed by the curriculum
- *Ability level* of student materials
- *Readability and physical appearance* for student's age
- *Teacher in-service training materials* and services available
- *Suggested* classroom organization/*management* of *curriculum*

Decision-makers appear to be generally similar to change agents in overall ranking of criteria.

Overall significant differences do exist among decision-makers, change agents, and curriculum developers/publishers as defined in this study. Decision-makers ranked

- *Approach* (e.g., concept, process, inquiry, discovery, discipline-centered, lecture)

lower than the other groups.

USING QUALITATIVE DATA IN FORMATIVE EVALUATION

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Objectives and Rationale

The purpose of this study is to explore the role of qualitative data in evaluating a science curriculum project which is in the midst of its development. Assets and limitations to the qualitative analysis technique are clarified. This is done in terms of its usefulness to curriculum developers.

Qualitative data are found by asking such questions as: What ideas have students learned? What misunderstandings have they still retained? The need for qualitative data and its use in a partial summative evaluation of Project Physics has been reported (Aikenhead, 1974).

It was claimed by Aikenhead that the technique of qualitative analysis would have greater applicability to formative evaluation than to summative evaluation. The specificity of the qualitative data over quantitative data was expected to give clear directions concerning what materials or activities needed revising or whether additional materials or activities needed to be added; and if so, what were their objectives.

Methodology and Design

A new kind of science course, Science: A Way of Knowing, is presently in the midst of development in Saskatchewan, Canada (Aikenhead, 1975). The course is an activity-centered, interdisciplinary approach to learning the processes, the nature, and the social interactions of science. The curriculum materials allow for a high degree of flexibility for teachers, in both the content of the course and how it is taught.

The present investigation is a pilot study related to the field development of Science: A Way of Knowing (draft #3). The developers wished to know:

a. What ideas have students learned about science and scientists?
b. What misunderstandings have they still retained?
c. How do the answers to the above questions vary among classes taught by different teachers?

These questions led to the one-group pretest posttest design using the McNemar chi-square item analysis (Cooley and Klopfer, 1963). At this stage in the development of *Science: A Way of Knowing*, there was no intention of comparing treatment with control groups.

The field testing groups were diverse. Six teachers taught *Science: A Way of Knowing* between 1974 and 1977; two in rural Saskatchewan schools, one in a Swiss international school, and the others in urban Saskatchewan schools from low to high middle class communities. The total student sample was 203.

Instruments and Data

The *Science Process Inventory*, SPI (Welch, 1973), and the *Test on the Social Aspects of Science*, TSAS (Korth, 1968), were administered during the first and last weeks of the course. A Kuder Richardson formula-20 measure for the sample was .85 for the SPI and .78 for the TSAS. Each item was analyzed by the McNemar chi-square statistic. This statistic identified test items which experienced a statistically significant increase or decrease in student response between the pretest and posttest.

Results and Conclusions

The items identified by McNemar's chi-square were grouped by their content. The following is a partial list of ideas for which student understanding dramatically *increased* ($\chi^2 > 10$, for df = 1): (1) the difference between science and technology, (2) the simplicity value, (3) the nature of scientific laws, (4) assumptions made by scientists, (5) the nature of scientific models, (6) the mythology of "the scientific method," (7) deduction, (8) the varying methods used by scientists, and (9) the role of imagination in formulating hypotheses. On the other hand, the few instances of "negative" learning suggested that students were applying oversimplifications to the situations they were asked to analyze.

Content areas were also identified for which gains were meager or for which misunderstandings were still prevalent in spite of the large gains made by a number of students. These included: (1) the analysis of an experiment in terms of its control and its variables, (2) induction, (3) the meaning of "tentative," and (4) a belief in "the scientific method."

For the SPI, student responses were very similar for all six teacher groups. However, there was great variation among the groups with respect to their TSAS results.

The qualitative analysis procedure proved to be a valuable tool in the repetoire of techniques used in formative evaluation. Specific examples will be cited which illustrate how material was altered and what activities were added in order to respond to the non-positive findings.

The qualitative analysis procedure has some inherent limitations. These relate to an omnipresent problem of assessing student learning: the problem of a student communicating to the evaluator what the student has learned. It is expected that this issue will be discussed by those attending the session.

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____________. "A New Kind of Science Experience in the High School." Paper presented at the 23rd National Convention of the NSTA, Los Angeles, March 22, 1975.

Cooley, William W. and Klopfer, Leo. "The Evaluation of Specific Educational Innovations." Journal of Research in Science Teaching, 1, 1963, 73-80.

Korth, Willard W. "The Use of the History of Science to Promote Student Understanding of the Social Aspects of Science." Unpublished doctoral thesis, Stanford University, 1968.

Welch, Wayne W. "Welch Science Process Inventory: Form D." Dr. Wayne Welch, College of Education, University of Minnesota, Minneapolis, Minnesota, 1973.

GENERAL SESSION II

Presiding: James R. Okey
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Speaker: NSF's New Direction in Science Education Research

F. James Rutherford (or a person designated by him)
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